 982

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AIR SERVICE MECHANICS

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The following publication, entitled "Information for Air Service Mechanics," is published for the information and guidance of all concerned.

[062.1, A. G. O.]

BY ORDER OF THE SECRETARY OF WAR:

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CHAPTER XIII.

DUTIES.

CONSTRUCTION OF HANGARS.

The airplane is housed in a hangar and on flying fields at the front; this hangar is made either of wood or of metal, usually corrugated iron. At training schools, tent hangars of canvas are frequently used. In some cases, hangars are of steel and concrete, with concrete floors and easily operated rolling metal doors.

DUTIES OF THE CREW CHIEF.

The hangar may be built to accommodate from one to six or eight airplanes. The crew chief has charge of the hangar and is held responsible for the condition of the airplanes, hangar, and tools of the crew. The crew chief directs the work, sees that the airplane is cared for properly, aligned correctly, its motor kept in the best of condition and its hangar clean and in good shape at all times. One of his duties is to hand to the section chief each day a written report showing the actual number of flying hours or hours in the air, of each airplane, the number of hours each motor has run, the names of pilots and passengers, and particulars of all parts and supplies used and requisitioned by his crew. He must see that extra parts in good condition are promptly turned in to storerooms and not left around hangar.

DUTIES OF CREW.

The crew, usually consisting of eight men, is held responsible for the condition of the airplanes in its charge. The machines must be ready to fly at any time of day or night, and all regulations providing for the proper care of the airplanes and the hangar must be carefully observed by the crew.

In performing the day's work, two men are usually assigned to complete charge of the engine, connections, controls, instruments, and propeller. They are responsible for its satisfactory condition. To the other men of the crew are assigned particular parts of the

airplane, each man being held personally responsible for the proper condition of the part assigned to him and for the prompt execution of his particular duties. All members of the crew assist in group operations, such as raising the fuselage and wing sections, moving the airplane, etc.

The object of every crew is to keep its airplane in the air for the largest possible number of flying hours. Everything is planned toward this end. Each man should be an expert in his particular work so that the airplane can be inspected closely, accurately, and quickly, so that it will be perfectly aligned when it takes the air and will fly successfully without bad landings, so that breaks may be

Fig. 61.—Airplane brought to flying line.

repaired as quickly as possible without outside help, and so that the routine details of the day's work may be handled smoothly and efficiently.

ORDER OF DAILY WORK.

At the beginning of the flying day, the engine men uncover the engine and propeller, connect the spark-plug terminals; the mechanics remove the blocking, and the airplane is rolled out on the flying line, facing the hangar. The engine men then pour in oil, water, and gasoline, start the motor and gradually warm it up by running it slowly.

The mechanics meanwhile go over the entire airplane, clean off all dust and dirt, oil all the wires, and put it in the best condition for flying.

The crew chief now inspects the airplane and next turns it over to the section chief for his inspection. After inspection by the section chief, the airplane is put on the flying line, facing toward the flying field. If strong wind is up, face airplane into wind. After bringing the airplane up to the line in the morning, the mechanics take up the rest of the day's work in the hangar, including overhauling of engines, repairing of parts, alignment of other airplanes, cleaning of hangar, and so on.

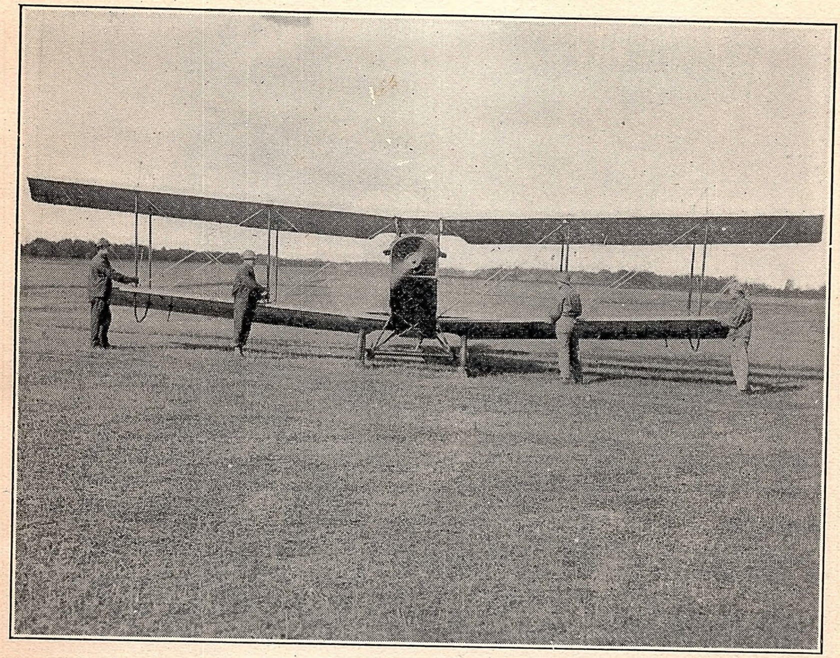

FIG. 62.—Airplane ready on flying line.

CARE OF HANGAR.

The hangar and its surroundings must be kept clean. Oil must not be allowed to accumulate on the floor at any time. If the hangar is a canvas tent, it must be securely fastened down. Tent pegs are to be driven in so they will point in the same direction as the pull of the rope fastened to them, and not at right angles to it. The end of the rope should be wound around the rope itself or coiled up, not left lying on the ground.

Where there is much windy weather, a stout anchor (in the shape of a 3 by 4 inch timber, about 30 inches long) can be put in the

ground, to which may be fastened the tent ropes. Bury this 3 feet underground in a horizontal position and fasten a piece of wire cable to its middle from which the ropes may be taken.

The tent poles should be straight and in alignment from side to side and from front to back. The tent itself should be kept clean and any holes promptly mended. The tools of the crew must be kept in the tool box and never placed on the ground or on the airplane.

TOOLS FOR THE CREW.

The following tools will be required for a crew of eight men:

For assembly and alignment:
- 3 pairs pliers, combination.
- 2 pairs pliers, diagonal cutting.
- 1 pair pliers, long-nosed cutting.
- 6 cotter pin extractors.
- 6 screw drivers, 6-inch.
- 6 crescent wrenches, 6-inch.
- 6 open-end wrenches, $\frac{1}{4}$, $\frac{5}{16}$ inch.
- 6 open-end wrenches, $\frac{3}{8}$, $\frac{1}{2}$ inch.
- 1 cold chisel.
- 1 flat file, 6-inch.
- 1 round file, 6-inch.
- 1 ball peen hammer, 12-ounce.
- 1 claw hammer, 8-ounce.
- 1 machinist's level, 12-inch.
- 1 pinch bar, 24-inch.
- 6 plumb bobs.
- 1 folding rule, 4-foot.
- 1 screw driver, 8-inch.
- 1 solid drive punch, 6 by $\frac{7}{32}$ inch.
- 1 steel tape, 50 feet.
- 1 bench vise, 2-inch jaws.

For hangar work:
- 2 shovels.
- 1 pick.
- Coil rope.
- 1 maul.
- 1 chain block.
- 1 hand ax.
- 1 saw.
- 1 carpenter's square.

Motor tools:
- 3 hammers, ball peen, 1 large and 2 small.
- 5 screw drivers, ranging in size from very long for heavy work to small and short for fine work.
- 7 pairs pliers, including 4 combination, 2 pairs cutting pliers and 1 pair round nose.
- 2 cotter pin extractors and spreaders.

Motor tools—Continued.

1 set wrenches, including 2 adjustable monkey wrenches, 1 Stilson or pipe wrench, 2 sizes adjustable end wrenches, 6 and 10 inch, and 6 double end wrenches, including Nos. 723 and 725, with sockets set at 60° with handle.
1 set of files, including flat, 3-cornered and half round.
1 file brush.
1 chisel.
1 drift pin, large.
1 drift pin, small.
1 hacksaw frame.
1 set hacksaw blades.
1 soldering copper.
2 long-handled stiff bristle brushes for cleaning motor.
1 gasoline blow torch.
1 hand drill.
5 spools safety wire.
1 electric flashlight.
1 oil can.
1 large adjustable monkey wrench.
1 washer and gasket cutter.
1 ball of heavy twine.
1 tire pump.
1 funnel.

Supplies including soldering acid, solder, shellac, valve grinding compound, bolts and nuts, cotter pins, washers, wood and machine screws, insulating tape, etc.

Special tools such as socket wrenches, spanners, puller, etc., will be required, these depending upon the kind of motor used in the airplane.

POLICING HANGAR.

Trestles, ladders, etc., must be kept neatly ranged at one end of the hangar when not in use. Blocking should be kept neatly piled. All rubbish, paper, etc., must be picked up and the hangar put in the best of order at the end of each day. The hangar must be well braced at all times, thus guarding against sudden windstorms and possible damage to the airplane.

CARE OF AIRPLANE AT NIGHT.

At the end of the flying day, the airplane is rolled into the hangar and blocked up with blocking under the ends of landing-gear struts and the tail skid. If in tent hangar, it is then tied down securely at the tail and also at the tip of each wing. The wing skid fitting is cast with a ring to pass the rope through. The radiator is drained if the weather is cold, the spark-plug terminals are disconnected, and the mechanic makes sure that switch is "Off." If tracks for the wheels are marked down center of hangar floor with streaks of light paint, wings will not be apt to strike the doors when airplane is rolled

in. In addition to the regular daily inspection each morning, the airplane is inspected after every flight and once a week, or oftener, depending upon the conditions under which it is flying, it is completely realigned.

BLOCKS FOR WHEELS.

The crew should make blocks to be placed in front of wheels when airplane is on the flying line with motor idling. A piece of $\frac{3}{8}$-inch rope should be attached to each block so that a mechanic at the tip of each wing can pull away the block when pilot gives him the signal without danger to himself.

FIRE DRILL.

A fire drill should be conducted at least once a week. Each man should be detailed to a particular duty and taught what he is to do in case of fire. This drill includes removal of airplane from the hangar and proper execution of their duties by the men detailed to the sand barrel, the fire extinguishers, and the fire hose.

DISPOSITION OF OIL.

After each day's flight the oil can be drained from the motor and allowed to stand in a pail over night, so that the dirt and sediment will settle at the bottom. The clean oil at the top is poured back into the motor next day and the sediment thrown out. Old oil is to be saved for reclamation. The following outline for daily field inspection gives a good idea of the duties of the crew.

DAILY FIELD INSPECTION.

MOTOR.

1. Inspect motor daily, and if you see anything about which you are in doubt and for which you have no instructions, report it at once to the engineer officer in charge.
2. Oil all working parts of motor, such as rocker arms, valve stems and tappets, etc., every morning and between flights, if necessary.
3. Look for bent, cracked, or broken rocker arms.
4. Look for weak or broken valve springs.
5. Check valve timing and see that no valves are holding open.
6. Clean spark plugs every four or five running hours.
7. Look for water leaks, gasoline leaks, and air leaks in manifold.
8. Check breaker points occasionally, and if they show signs of burning, call to the attention of the motor expert.
9. Wells in carburetors should be emptied of all water or obstructions that may have collected.

10. Draw off oil from sump of motor after every 15 hours running and refill with fresh oil, water in radiator to be changed every 15 hours. Motor should be overhauled after every 75 hours running or oftener if necessary.

11. In case of serious motor or airplane trouble, report it at once to trouble shooter and officer in charge.

FUSELAGE.

12. Tires should be inflated so that they stand full and round under weight of machine. When airplane skids in landing, tire will be thrown if it is not pumped up to correct pressure.

13. Wheels should be taken off occasionally to see that the place prepared for grease is filled. If this is not done, the wheels are liable to freeze, thereby causing an accident in landing or getting off.

14. The bronze bushing in the hub should be examined for wear and looseness when the wheels are greased. Wheels should be inspected daily for loose spokes. These are dangerous, as with them a little side thrust will cause the wheel to collapse. Examine wheels for loose spokes when weight is on them.

15. Wing sections are very important and must be carefully looked over. All braces and beams should be tested by light blows with the hand to see that they are not cracked. Such cracks will not show up in simply looking over the airplane.

16. Struts should be examined for bows, often caused by wires pulled up too tight.

17. Where the control wires run through ferrules or around pulleys, they should be watched very closely for breaks in the strands or frayed strands. When putting a control wire around drum on wheel post, be careful not to cross it or twist two wires around each other, as they will fray from rubbing together and perhaps jam. Controls should be firmly drawn up, but not so tight as to make them work too hard.

18. All wires and pipes that have any opportunity to rub and wear must be covered with tape and made fast.

19. In tightening wires, care must be taken that the tension on them is not so great as to cause undue stress on other wires or struts or such as to cause distortion of fuselage. This is particularly true of the center section panel and its wires.

20. Fuselage should be cleaned out once a week, after removing inspection cover. Wires should be cleaned off, wiped with an oiled rag, and tested.

21. Carefully examine pilot's seat and see that it is securely fastened and fitted in place and that the safety belts are well made and stoutly fastened.

22. Inspect motor and airplane after each flight.

23. Airplane should be realigned weekly or after any flight causing extraordinary strains.

GENERAL.

24. Airplanes will be kept properly supplied with gasoline, oil, and water and tires properly inflated.

25. Airplane should be ready to fly at any time, day or night.

26. Hangars must be swept daily and oil waste and papers removed.

27. Each crew is responsible for the policing of the outside of its hangar.

28. Each crew chief is held responsible for the handing in of flight reports at the end of each day.

29. When in the hangars, airplanes shall be placed so as to permit easy removal in case of fire or other emergency. Thoroughly secure the doors after closing. If doors are in need of repair, report the matter at once. Cover motor and propeller with their canvas covers. Allow no civilian visitors in your hangar or within 10 feet of your hangar at any time.

30. To lift the wings for blocking up wheels, etc., take hold of beam near outer front strut.

31. Gasoline and oil must be kept away from fabric, rubber shock absorbers, and tires.

32. Always use chamois in filling gas tanks. Make sure your gas cans and funnels are clean and free from dirt.

33. A fire extinguisher will be kept in each airplane. Inspect fire extinguishers often and refill if necessary. Do not light a lantern near airplane. Keep the blow torch away from the gas tank. Smoking in the vicinity of the airplane or gas tanks is prohibited. Do not put water on an oil or gasoline fire, as it will cause it to spread and make it worse. Use pyrene, sand, or dirt.

34. A piece of hard wire or a nail should be used in turning turnbuckles. All the threads of a turnbuckle should be covered. Turnbuckles should also be safety wired. No two turnbuckles should be safetied with the same piece of wire. Turnbuckles that have been bent and straightened again are to be replaced at once. Never enlarge the hole in the end of a turnbuckle.

35. Cotter pins that have been removed should never be used again.

36. At no time will anyone be found near a propeller or in line with the tips of the propeller. The signals to be used by pilots and men cranking machines are "Off" and "Contact." No other words will be used. In working around an airplane or propeller, the man doing the work must first make sure that the switch is off.

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37. In taxying to and from hangars one man must be on each wing. Do not support wings by edges or struts; hand grips must be used. Taxi at slow speed.

38. Planes may be taxied to end of flying field; then motors must be shut off and planes rolled to positions in hangars. Planes must never be taxied to position between hangars.

39. All airplanes scheduled for flight shall be on flying field, in line, with motors turning over slowly, at appointed hour.

40. In case of an airplane being wrecked, or partially wrecked, the crew of that machine, the emergency crew, and the detachment of the medical corps will go to the scene of the wreck. No one else except the officer in charge of flying, engineer officer, and their assistants will be allowed to go to the scene of the wreck.

CHAPTER XIV.

THE WRECKING CREW.

DUTIES OF LOOKOUT.

A lookout with telescope is stationed in an observation tower, whose duty it is to keep a watch on all planes in the air. In case he sees a ship fall or make a forced landing, he immediately phones to (1) the engineer of post, (2) officer in charge of flying, (3) engineering and repair shop, (4) commanding officer of the post. Ambulance with doctor and driver is stationed within flying circle of field, and if the fall is seen from circle the ambulance is ordered to go to wreck by officer in charge of flying, who is always in the circle while flying is going on. The lookout must always be able to tell how many airplanes are out of sight (in air) and in which direction they went. He is equipped with anemometer, and can give speed of wind when called for.

DUTIES OF WRECKING CREW.

The duty of the wrecking crew is to take care of all airplane wrecks on the field. As a rule, a separate crew is used for wrecks which have occurred at some distance from the flying field on cross-country flights.

The wrecking crew, the officer in charge of flying, the engineer officer and his assistants are the only men permitted to cross the white dead line and approach a wreck. This rule is strictly enforced on every field.

The wrecking crew usually consists of a chief and not less than 10 men. They are provided with a Ford automobile and full equipment. The engine is kept running and the automobile is placed facing at a 45° angle toward the landing place, at which place most accidents occur. If for any reason the wrecking crew should leave the field or the automobile get out of order, the officer in charge of flying should be notified at once and flying should be suspended temporarily.

The wrecking crew will be on the field at least 10 minutes before flying time, will report to the officer in charge of flying, and then place the proper field markers and wind funnels to indicate the direction of the wind. These will be under their charge, and they will make necessary changes throughout the day to meet weather conditions.

No man is permitted to leave the crew unless a substitute is provided first. The crew must be in its place ready to proceed to a wreck on a moment's notice when an airplane has landed in distress. The pilot must be extricated, the gasoline shut off, the degree of damage to the airplane determined, and a dolly placed under the airplane for towing it off the field if necessary.

FIG. 63.—A typical wreck—Canadian Curtiss biplane.

HANDLING OF WRECKS.

If the wreck on the field is a bad one, the Ford returns at once for the motor truck and the crew of the wrecked airplane. The airplane can easily be loaded on the truck by removing the truck sides and lifting the airplane on the body of its wings and tail.

The wrecked airplane is then returned to its hangar and the engine cover and sides removed for inspection. After the inspection by the assistant engineer officer, the airplane should be repaired at once on the field if possible or if so ordered should be sent to the aero shop. When a longeron has been broken, the latter is always necessary.

If the airplane is sent to the aero repair shop, the engine should be taken out and sent to the engine shop for overhauling and in-

spection. If the wreck has been of such a nature that the crankshaft might be sprung, the motor should not be used again until it has had the most thorough inspection.

REPORT ON WRECKS.

After the inspection, the crew chief makes a detailed report on the wreck (explained in chapter on "Field Records") and turns it in to the proper office.

The crew chief of the airplane turns in the total time of the motor and airplane to the motor shop and aero repair shop. No wrecks should be left in hangars and no part of the wrecked airplane should be removed under any circumstances.

The crew chief is absolutely responsible for the airplane as long as it is in his charge. He will be held responsible for any missing parts or instruments.

When the airplane makes a forced landing on account of engine trouble or some minor trouble, the wrecking crew can repair the damage and crank the propeller. If the landing has been a bad one, however, and there is a possibility that some part may be broken or bent, it is best to return the airplane to the hangar for a complete inspection.

WRECKS DISTANT FROM FLYING FIELD.

When the wreck occurs off the flying field, the separate wrecking crew detailed for this work goes at once to the scene with a Ford and motor truck. The noncommissioned officer in charge of this crew is notified by the officer in charge of flying and takes with him the crew of the wrecked airplane in addition to his own.

WRECKING CREWS EQUIPMENT.

The equipment listed below is taken, together with a box containing the necessary kitchen equipment and utensils for a long trip. This box is always kept in readiness for such trips, in the kitchen of mess hall of the squadron which has been designated to furnish cook and rations for such a trip.

Prescribed wrecking crew equipment:

5 small pyrenes, gallon capacity.
2 fire extinguishers.
2 buckets of sand
2 bolt cutters.
One 2-inch heavy eccentric nippers.

Prescribed wrecking crew equipment—Continued.

1 axe.
1 jack.
2 extra wheels.
2 4 by 4-inch stringers 12 feet long.
50 feet No. 18 copper safety wire.
Two 50-foot rolls $\frac{3}{4}$-inch rope.
1 dolly.
One $1\frac{1}{2}$-ton wooden block and tackle, with 50-foot take up drag length.
1 gallon can of dope.
One 3-inch brush and paint can.
4 pairs blacksmith's wire nippers.
2 square yards linen.
One 5-gallon can water.
One 5-gallon can gasoline.
1 funnel and chamois.
One 5-gallon can lubricating oil.
1-gallon measure for oil.
2 propeller pullers.
1 bucket, $3\frac{1}{2}$ gallons.
2 sets propeller wrenches and steel rods.
2 extra wing skids.
1 extra propeller.
50 yards cheesecloth.
24 extra spark plugs.
4 complete tool kits, each containing the following:
    2 pairs 6-inch combination pliers.
    1 pair diagonal cutters.
    2 cotter pin extractors.
    One 3-inch ratchet screwdriver.
    One 10-inch ratchet screwdriver.
    One 16-inch screwdriver.
    1 spark plug wrench.
    1 thickness gauge.
    1 magneto wrench.
    One 4-inch Crescent wrench.
    One 6-inch Crescent wrench.
    One 8-inch Crescent wrench.
    1 No. 1 engine brush.
    1 small can containing assortment of cotter pins.

PRESCRIBED EQUIPMENT FOR FIELD WRECKING CREW.

The Ford with the crew goes on ahead of the truck so as to get the disassembly of wrecked airplane under way before the truck arrives. The noncommissioned officer at once ascertains the cause of the wreck from the pilot and takes notes of any circumstances worthy of report, such as the field picked for landing, the method of tying down the airplane, etc.

The airplane will be immediately repaired or disassembled for loading upon the truck and the return trip commenced as soon as possible.

NECESSITY OF CAREFUL WORK.

The crew should be required to do careful and orderly work and parts should not be needlessly cut or broken in removing the wreck. Nippers should be used only when fittings are caught under the engine or when the pilot himself is trapped under the airplane.

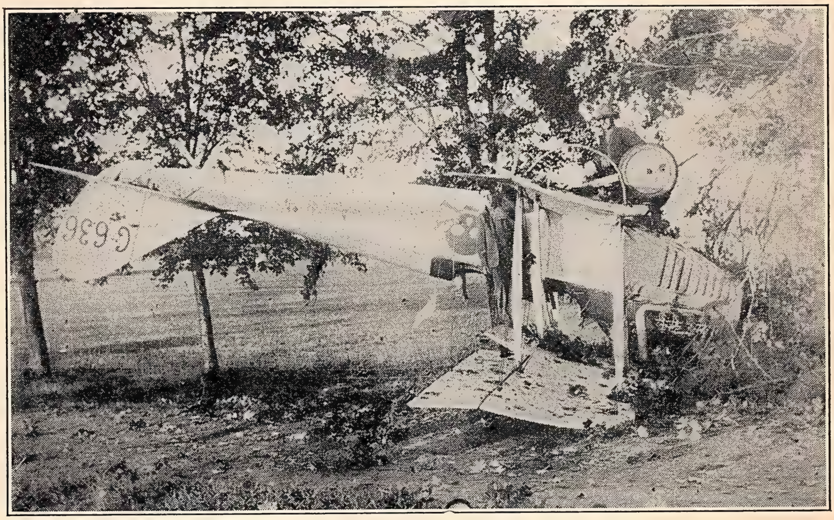


FIG. 64.—Canadian Curtiss biplane landed in tree and turned over.

Every part of an airplane is expensive and delicate and the utmost care should be exercised to preserve every useful part and to prevent needless expense. The crew chief should explain the correct procedure to the men and should hold each one individually responsible for exact obedience to orders, inspecting their work when the airplane is on the truck to see that his instructions have been followed to the letter.

CHAPTER XV.

THE AERO REPAIR SHOP.

RELATION OF SHOP TO THE FIELD.

The number of airplanes available for use on any flying field depends largely upon the efficiency of the aero repair shop. Demands are continually being made upon the shop for parts, repairs, and tests, and it takes a properly organized and well-maintained shop to meet them all. Aero repair-men must be manufacturers as well as repairers, for it is necessary to keep a fair stock of new parts on hand. The various departments comprising the aero repair shop must be manned by capable, experienced, and rapid workmen. Advancement in this branch is quite rapid, for it is recognized that much depends upon the work of the conscientious repair man.

ROUTING OF WORK.

A defective or damaged part is taken by the hangar man to the stock room of the aero repair shop and turned in. In exchange for it he is given a requisition for a new part which he presents at the proper department of the repair shop. He is given the new part and delivers it to the hangar. Minor repairs, of course, are made in the hangar. The stock clerk of the aero repair shop keeps a record of all parts received and delivered and makes a note of repairs to an airplane on the loose-leaf record of the airplane which is kept with it and accompanies it on its travel. Very little clerical work is thus left to the hangar man, it being only necessary for him to keep an account of the airplane's flying time and motor time.

DUTIES OF REPAIR-SHOP STOCK ROOM.

On a single unit field, the various departments of the aero repair shop perform the following duties:

Stock-room duties are:

(*a*) To order materials and supplies for all departments.

(*b*) To receive and check all damaged and defective parts.

(*c*) To record and account for all parts, new or damaged.

(*d*) To keep a record of each airplane as regards its falls, repairs, etc., in a loose-leaf "history."

(*e*) To issue parts and materials to field hangars. The stock room must be carefully and efficiently managed if the duties for which it is held responsible are to be capably and promptly executed. Complete and accurate records must be ready at all times, showing every new and defective part received or issued. Raw materials for new parts must be in stock and this must be ordered far enough ahead to allow for unavoidable delays in the transmission of orders. Certain parts which can not be manufactured in the shop must be kept in stock, and enough of them to meet all demands promptly. On the other hand, the most efficient manager is always known by his economical use of materials and supplies, and the primary purpose of the aero repair shop is one of wise economy. A history of the airplanes on the field is kept, showing the nature of each accident, names of parts damaged, and date of delivery of new parts.

DUTIES OF WOODWORKING DEPARTMENT.

(*a*) To make up and supply to stock-room all wooden parts of the airplane.

(*b*) To repair wing and other panels.

(*c*) To repair propellers.

The call for landing-gear struts is always an insistent one, and the woodworker must be able to make them quickly and well. He must be able to handle hand and machine equipment and to select suitable material for the different parts, as well as to cut it to the best advantage. So much depends upon the wing panel that the greatest responsibility rests upon the wing repairmen, and some of the best men are always assigned to this work. A careless workman can not be tolerated in this department. An apparatus for bending the wing skids, which are so frequently broken must be made up. The heavy work imposed upon the propeller necessitates the best of workmanship in its repair. A propeller which has been repaired is used in an eight-hour run of the motor upon the block before it is tipped, thus insuring its reliability.

RULES OF SHEET METAL DEPARTMENT.

(*a*) To make fittings for parts in stock and as ordered.

(*b*) To make and repair oil and gasoline tanks.

(*c*) To manufacture gasoline lines.

(*d*) To clean and repair radiators.

Specially designed tanks and equipment are often made here. Extra large tanks are made for cross-country flights. The sheet

metal workers must be fast and accurate. Airplanes with nonrigid tanks such as the Standard cause the most trouble for the metal workers, as the vibration of the airplane causes the rapid deterioration of the metal. Metal parts and fittings which are broken in bad landings help to supply work for this department.

DUTIES OF WIREWORKING DEPARTMENT.

(*a*) To manufacture wires and cables for stockroom.

(*b*) To manufacture wires to order.

(*c*) To keep in good condition, indexed and labeled, all lengths of wire on hand.

The wireworker must not only shape and solder his wires correctly but must cut them to the right lengths. This detail is very important, as a quarter of an inch difference in a wire's length may make it useless, and a careless wireworker will cause endless trouble. The wires in stock must be carefully assorted and labeled for prompt delivery.

DUTIES OF LANDING GEAR DEPARTMENT.

(*a*) To assemble landing gears.

(*b*) To recover parts from wrecked landing gears. The work of the landing gear department is highly important, as more landing gears are broken than any other single part of the airplane. The number broken depends directly upon the skill of the riggers in alining their airplanes correctly so that they are properly balanced, the conditions of the field and of the weather and the proper condition of the landing gear struts.

DUTIES OF VULCANIZING DEPARTMENT.

(*a*) To repair tires for motor trucks, automobiles, and airplanes. This department can make or save a great deal of money for the field if it is properly organized and put in charge of a competent vulcanizer. The work can be done economically and the injured tires restored to the best of condition.

DUTIES OF FUSELAGE REPAIR DEPARTMENT.

(*a*) To realign fuselage.

(*b*) To splice longerons and replace broken parts.

(*c*) To remodel airplanes as ordered.

A workman who can align a fuselage so that it will stay in correct alignment is a valuable man in the aero repair shop. As it takes weeks of practice to acquire the little kinks of this trade, as much

time as possible should be given to training the new men in this work. A fuselage is frequently twisted in aligning the landing gear. This is because factory-made struts for the landing gear often vary in length and when the landing gear is trued up the fuselage is pulled out of shape.

COMMON FUSELAGE TROUBLES.

In airplanes having antidrift wires, these wires are often pulled so tight that the longerons are bowed, the strut tips are broken, and the fuselage bracing wires are loosened, thus giving the tail an angle of incidence. The airplane will be tail heavy and it will be very difficult to make it fly correctly. Great care should be used in selecting the material for master struts and engine beds. These are frequently broken in bad landings but when the best material is put into them the percentage of breaks will be smaller. When an engine bed breaks, the entire engine will be almost racked to pieces.

A good man on longerons is necessary. If a longeron is an eighth of an inch out, the whole fuselage will be thrown out of alignment, the airplane will be a "grasshopper" when taxying and it will be necessary to replace the faulty longeron with a new one.

DUTIES OF SAIL-MAKING DEPARTMENT.

(*a*) To cover wings and fuselages.
(*b*) To repair holes in fabric.
(*c*) To dope and varnish fabric.
(*d*) To paint insignia and number on fabric.

The covering of entire wings and fuselage is not a frequent operation but the patchers in this department are always busy. Wings and panels, salvages from a wreck, have cuts made in the fabric and their internal structure is closely scrutinized for possible breaks. These cuts must be neatly repaired and the repairs must be as little in evidence as possible for it is plain that cadets will be unready to fly an airplane that has patched and mended wings. Their fears are well grounded if the work of inspecting and mending the panels has been poorly done.

As the chemical used in the dope gives off disagreeable fumes, men engaged in doping are transferred from inside to outside work at regular intervals.

DUTIES OF WELDING DEPARTMENT.

(*a*) To weld metal parts.
(*b*) To straighten axles, rods, etc.

On some fields broken parts of both engines and airplanes are welded in one shop, but the ordinary day's work of the welder takes

in the straightening of axles, bracing members, and the like. In some cases it is not considered safe to straighten a bent part and a new one must be made. A poorly welded member is worse than a broken one.

DUTIES OF EXPERIMENTAL AND TEST DEPARTMENT.

(*a*) To inspect and test all salvaged parts from wrecked airplanes.
(*b*) To test repaired wings, wires, cables, and struts.
(*c*) To design and make up new accessories as ordered.

The testing of salvaged parts must be done carefully. When a wing is brought in from a wrecked airplane, it is placed on a rack and subjected to a weight bearing the proper rotation to its factor of safety. While it is under stress, L-shaped incisions are made between each pair of ribs along both spars and an electric light is placed inside the section to be examined so that a close inspection can be made. A spar that does not measure up to the specifications under pressure is discarded, especially if it shows no signs of a break, the supposition being that it is strained internally. If a break is found somewhere near the end, the wing is passed on to the woodworkers for repair. After their work is completed, a second test follows before the wing goes to the sailmakers. Wires, struts, etc., are subjected to appropriate tests for tensile or compressive strength and after testing they are passed on to the stockroom for issue. This department carries on experimental work connected with new appliances and the instruments used on the airplane.

DUTIES OF WRECKING DEPARTMENT.

(*a*) To disassemble and salvage wrecks.
(*b*) To remove motors from wrecks.
(*c*) To pack wrecks for shipment to repair depots.

When a wreck arrives at the aero repair shop, it is turned over to the working crew. The extent to which it is damaged determines the disposition made of it. The engine is first removed from the airplane and turned over to the engine repair crew. If the fuselage can not be repaired on the field, it is turned over to the fuselage department. If too badly damaged for this, it is crated for shipment to the repair depot. If there is no possibility of saving the fuselage, the wrecking crew tears it down, saving and assorting good parts and fittings and turning them in to the test department. The wings and empennage are either condemned or sent for test to the M. S. E. or lieutenant in charge. When condemned, they are carefully taken apart so that all good parts may be used again, and thus obviate the necessity of making new wing ribs, cap strips, etc.

DUTIES OF ASSEMBLING DEPARTMENT.

(*a*) To assemble and make ready for motor all airplanes entering shop for repairs.

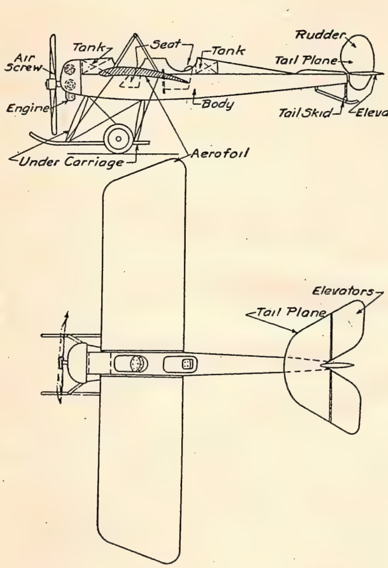


FIG 65 TRACTOR MONOPLANE

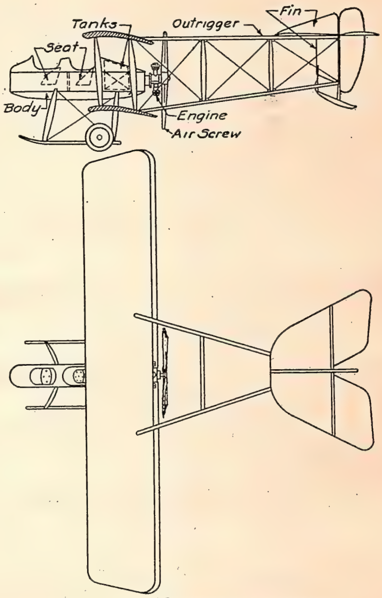
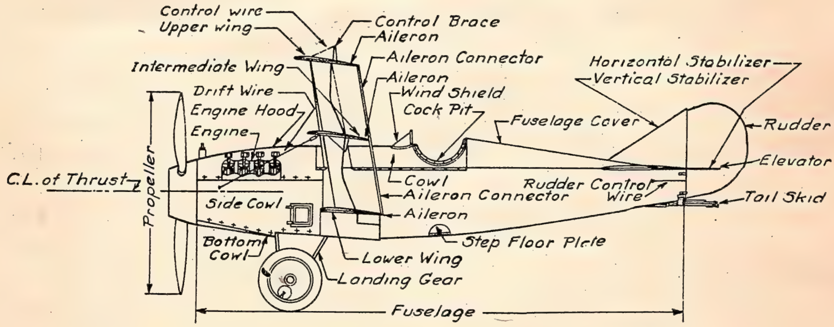


FIG. 66 PUSHER BIPLANE

FIGS. 65 and 66.—Tractor monoplane; pusher biplane.

When a fuselage is turned over to the assembly crew, they rig it up and get it ready for the motor, using old or repaired panels and



CURTISS PURSUIT TRIPLANE

FIG. 67.—Curtiss pursuit triplane.

report to the M. S. E. in charge when the airplane is ready for inspection. It is then sent to its original hangar.

CHAPTER XVI.

ORGANIZATION CHART OF SINGLE UNIT AERO REPAIR SHOP.

ADMINISTRATIVE.

Department of subdivision.	Number.	Rank.	Position.	Directly responsible to—	Duty.
	1	First lieutenant.	In charge.....	Engineering officer.	General administration.
	1	Second lieutenant.	Assistant.....	Lieutenant in charge.	Assistant manager.
	1	M.S.E..........	Foreman.....	Above officers.....	General executive.
1. Stockroom.......	1	Sergeant........	In charge.....	Lieutenant in charge.	In charge of billing, reports, inventory, etc.
	1	Corporal........	Assistant.....	Sergeant in charge.	Assistant above.
	1	Private..........	Clerk..........	.....do............	Handles field requisitions.
2. Wood work: A. Wing repair.	1	Sergeant........	In charge.....	M.S.E.............	Supervision of wing repair.
	3	Privates.........	Repairmen...	Sergeant in charge.	Make all wing repairs.
B. Propeller....	1	Sergeant........	In charge.....	M.S.E.............	Charge of property repair, balance.
	1	Corporal........	Patcher......	Sergeant..........	Assistant sergeant in wood repairs.
	1	.....do...........	Tinner.......	.....do............	Tips new and repaired props.
C. Strut making	1	Sergeant........	In charge.....	M.S.E.............	Supervises strut making.
	2	Privates.........	Woodworkers	Sergeant..........	Make struts and wooden parts.
3. Wire work.......	1	Sergeant........	In charge.....	M.S.E.............	Checks wire in and out, supervises wire work.
	2	Privates.........	Wire makers.	Sergeant..........	Make up wires as ordered.
4. Sheet-metal work	1	Sergeant........	In charge.....	M.S.E.............	Supervision.
	1	Private..........	Sheet metal..	Sergeant..........	All fittings.
	1	.....do...........	.....do.......	.....do............	Tanks.
	1	Corporal........	.....do.......	.....do............	To mend and clean.
	1	Private..........	.....do.......	.....do............	Radiators.
5. Landing gear....	1	Corporal........	In charge.....	M.S.E.............	Save parts wrecked gear.
	2	Privates.........	Helpers......	Corporal..........	Oversee assemblies.
6. Vulcanizing......	1	Sergeants.......	In charge.....	M.S.E.............	Receive and check out jobs; chief repairman.
	1	Corporal........	Assistant.....	Sergeant..........	Vulcanizer.
7. Fuselage repair...	1	Sergeant........	In charge.....	M.S.E.............	Supervise repair and alignment.
	1	.....do...........	Rigger.......	Chief..............	Check and align fuselage and hangar jobs.
	1	Corporal........	Woodworker.	.....do............	To splice longerons.
	2	Privates.........	Riggers......	.....do............	Replace broken members.
	1	Corporal........	Rigger.......	.....do............	To remodel as ordered.
8. Fabric and dope department.	1	Sergeant........	In charge.....	M.S.E.............	General supervision and records.
	1	Corporal........	Assistant.....	Sergeant..........	Assistant supervision.
Patching.......	4	Privates.........	Patchers.....	Corporal..........	Repair fabric in hangar.
	2	.....do...........	.....do.......	.....do............	Repair wings on planes and ships in shop for repairs.
Stitching	2	.....do...........	Hand stitchers.	.....do............	Make leather guide.
	1	Corporal........	Machine stitchers.	.....do............	Make covers for wings.
	1	Private..........	.....do.......	.....do............	Fuselage, props, etc.
Dope...........	1	Corporal........	Painter......	.....do............	Dope, varnish, and paint.
	1	Private..........	.....do.......	.....do............	Fabric.

Organization chart of single unit aero repair shop—Continued.

ADMINISTRATIVE.

Department of subdivision.	Number.	Rank.	Position.	Directly responsible to—	Duty.
9. Welding	1	Sergeant	In charge	M.S.E	Keep records, supervise and make repairs.
	1	Corporal	Assistant	Sergeant	Repair and make fitting requiring welds.
10. Experimental and test.	1	Sergeant	In charge	M.S.E	Supervise, checks in-and-out test, sends for repair, wires from rex.
	1	do	Tester	Chief	Tests wings, wires, etc. after repair.
	2	Privates	Helpers	do	Assist in above work.
11. Wrecking	1	Corporal	In charge	M.S.E	Receive and account for salvage.
	5	Privates	Helpers	Corporal	Disassemble wrecks and take salvage to test department. Pull motor from wrecks.
12. Assembling	1	Sergeant	In charge	M.S.E	Supervise, inspect, and account for alignment of airplanes from shop. Subject to O.K. by lieutenant or M.S.E.
	4	Privates	Riggers	Sergeant	Assist in assembling ships.

CHAPTER XVII.

FIELD RECORDS.

The following field records, among others, are now in general use on the flying fields:

Airplane condition record.
Record of receipt of airplane.
Daily airplane crew report.
Daily airplane report.
Daily report of aero gasoline and oil.
Airplane flight-time record.
Engine running-time record.
Wreck report.
Accident report.
Supply requisition.
Engine-inspection report.

AIRPLANE CONDITION REPORT.

This report is supposed to accompany the airplane on its travels and shows the exact condition of the airplane and all of its parts. The details given in this report relieve the receiving officer at a flying field from any blame attached to him, because of defective parts on an airplane which occurred previous to his receipt of it.

RECORD OF RECEIPT OF AIRPLANE.

This report is made out after airplane received in a shipment is unpacked and assembled. If airplane is received in bad condition, this report makes it possible to fix the responsibility for the damage.

DAILY AIRPLANE CREW REPORT.

This report is made out every day by the crew chief or his assistant, and as soon as the day's work is over it should be turned in to the engineer officer. This gives the flight time and the engine running time, together with the gasoline and oil used, and enables the

engineer officer to keep an exact tab on the work of each crew. When the total airplane and motor time has been checked up for the day it should immediately be posted at the top of the next sheet so that crew chief can carry forward his record of the total flying and engine running time.

DAILY AIRPLANE REPORT.

From the daily airplane flight report the engineer officer is able to make up the daily airplane report, showing the total number of airplanes in commission and out of commission, together with the reason for the conditions shown by the report. The flying time of each field and the total number of airplanes in and out of commission are telegraphed to Washington at the close of each day. The report of the crew chiefs must be regularly made out and handed in, so that the daily airplane report can be promptly made up and the results telegraphed.

MOTOR AND PLANE REPORT BOOK.

In some flying fields motor and plane report books give a complete record of the airplane and its motor and are kept always with the airplane, being placed in pockets inside the fuselage. The motor report book accompanies the motor when it is removed from the fuselage for repairs, and it accompanies the motor on all its travels. These books contain the details which are given here on the daily airplane flight time record and engine running time record.

DAILY REPORTS ON AERO GASOLINE AND OIL.

This report is made out every day by the man in charge of these supplies and is forwarded to the engineer officer. It enables an accurate check to be kept on the consumption of oil and gasoline, and recommendations as to the kind of oil and gas desired can be filled in at the bottom of this report.

AIRPLANE FLIGHT TIME RECORD.

The airplane flight time record is made out for every airplane each month, and is a summary of daily flight time reports taken from daily airplane crew chief's report.

ENGINE RUNNING TIME RECORD.

One of these reports is made out for every engine for each month, and is a summary of the daily running time given on the daily airplane crew report. The above two reports permit a complete record

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of each airplane and engine to be kept in comparatively small space—12 sheets sufficing for the work of the entire year.

WRECK REPORT.

A noncommissioned officer or his assistant who is in charge of the wreck report must be on the flying field at all times during the flying day. When a machine is wrecked or damaged, he must proceed to the scene of the accident, secure full particulars of the accident, and immediately make out the wreck report shown here, and, if necessary, make out the accident report as well. A wrecked airplane should be returned to its hangar, where a detailed inspection can be made. If the longerons are broken and the machine is in bad shape, the officer in charge of the wreck orders it to the aero repair shop. Before the airplane is sent to the shop the motor is removed and taken to the motor repair shop. The wreck report is taken to the officer in charge of flying at the observation tower, who adds any comments or statements of his own to the report.

ACCIDENT REPORT.

The accident report is made out more particularly for accidents occurring on the flying field itself, and gives the airplane and motor numbers.

SUPPLY REQUISITION.

Each crew chief keeps supply requisition blanks on hand, and any material such as tools, ordered from the field supply office, must be ordered on these requisition blanks.

RECORD BOARD IN HANGARS.

A record board is kept in every hangar on which the crew chief posts all notices in regard to flying hours and orders from the engineer officer and from the officer in charge of flying which directly affects the crew of the hangar.

ENGINE INSPECTION RECORD.

The engine inspection record will be made out to show the exact condition of the engine and also to give an exact record of repairs made on the engine.

CHAPTER XVIII.

AIRPLANE SPECIFICATIONS.

BRISTOL FIGHTER F–2B (190-HORSEPOWER ROLLS-ROYCE).

List of principal dimensions.

Span of upper and lower main planes	39 feet 3 inches.
Chord of upper and lower main planes	5 feet 6 inches.
Incidence of upper and lower main planes	1¾°.
Dihedral of upper and lower main planes	3½°.
Stagger	[1] 16.9 inches.
Gap	64½ inches.
Over-all length	26 feet 2 inches.
Height	8 feet 9 inches.
Incidence of tail plane with hand lever in mean position	½ to ¾ inch.
Droop of ailerons, with pilot's control stick central	¾ inch.
Elevators (with pilot's control stick central)	Horizontal.
Weight in pounds:	
Weight light, including guns and mountings complete	1, 700
Military load (ammunition)	150
Human load	360
Fuel, oil, and water (tanks full)	440
Total	2, 650

POINTS TO BE OBSERVED WHEN OVERHAULING MACHINE.

See that the leading edges of the main planes are symmetrical about center line machine.

Examine the bracing wires for length and tautness in the center section, and see that the split pins are in position.

Check the dihedral.

Check the stagger.

Check the incidence.

See that the interplane struts are straight.

Examine all main plane bracing wires for length and tautness, and see that all split pins are in position and that all turnbuckles on cables are locked.

[1] In machines Nos. A 7177 and B 1101 onwards the stagger is 18.1 inches (July 9, 17).

Examine all controls, control pulleys and cables, and see that they work freely.

Examine tail plane and see that it is set correctly and is square with machine, and that all tail plane bracing wires are correct both as to tautness and length, and that all split pins are in position.

Examine tail plane actuating gear and see that it works freely.

Examine rudder and fins and see that they are set straight and square with machine.

Measure the droop of the ailerons and elevators.

Examine undercarriage and skid.

Examine tank mountings and connections.

Examine engine mounting, engine controls and engine accessories.

BRISTOL FIGHTER F–2B (200-HORSEPOWER HISPANO-SUIZA).

In the case of the 200-horsepower Hispano-Suiza machine—

(*a*) The dihedral is $3\frac{1}{2}°$ for the front spars only on account of "wash out" on both sides. Check by Abney level and straightedge along the front spars only.

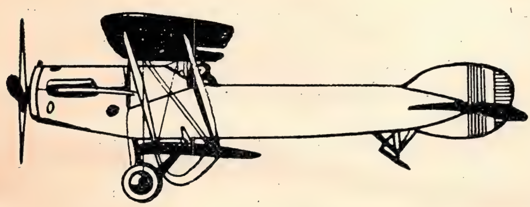

FIG. 68.—The Bristol fighter, 1917.

(*b*) The stagger is 19.7 inches throughout. Check by measuring the horizontal fore and aft distance between the leading edge of lower main planes and plumb lines dropped from the leading edge of upper main planes. These measurements should be 19.7 inches.

(*c*) The incidence is—

(i) 1° 42 feet at center section.

(ii) 1° 24 feet at inner interplane struts on both sides.

(iii) 1° at outer interplane struts on both sides.

Check by Abney level and straightedge, placing the latter from leading edge to trailing edge at ribs.

Proceed otherwise as in the 190-horsepower Rolls-Royce machine.

BRISTOL FIGHTER F–2A (190-HORSEPOWER ROLLS-ROYCE).

TRUING UP THE FUSELAGE.

In this machine the fuselage is symmetrical in both plane and side elevation. Therefore in truing it up the middle points of all cross struts, top and bottom, should be in the same vertical plane, while the middle points on all side struts must be in the same horizontal plane.

In this machine there is no lower center section plane, and the lower main planes are attached to a wing anchorage frame which allows of lateral adjustment only.

Otherwise proceed exactly as in *F–2B*.

List of principal dimensions.

Span of upper and lower main planes	39 feet 3 inches.
Chord of upper and lower main planes	5 feet 6 inches.
Incidence of upper and lower main planes	$1\frac{3}{4}°$
Dihedral of upper and lower main planes	$3\frac{1}{2}°$
Stagger	17.1 inches.
Gap	64.5 inches.
Overall length	26 feet 3 inches.
Height from ground to highest point of machine	11 feet 2 inches.
Tail span	12 feet.
Incidence of tail plane with hand lever in mean position	$\frac{1}{2}$ inch.
Droop of ilerons (with pilot's control stick central)	$\frac{3}{4}$ inch.
Elevators (with pilot's control stick central)	Horizontal.

Weights, in pounds:	
Power unit dry	874
Aeroplane	853
Military load	180
Human load	360
Fuel, oil, and water	400
Total	2,667

DE HAVILAND NO. 5 (110-HORSEPOWER LE RHONE).

List of principal dimensions.

Span of upper and lower main planes	[1] 25 feet 8 inches.
Chord of upper and lower main planes	4 feet 6 inches.
Incidence of upper and lower main planes	2°
Overall length	[1] 22 feet.
Height	[1] 9 feet.
Gap	5 feet.

Stagger: A plumb line dropped from a point 2 inches in rear of center line of front spar of upper center section. Plane must strike a point $3\frac{1}{2}$ inches in rear of center line of rear spar of lower center section plane.

Dihedral (for both upper and lower main planes)	$4\frac{1}{2}°$
Allowance for propeller torque, incidence at port: Outer interplane struts	$2\frac{1}{4}°$

Incidence of tail plane: Tail plane set in the third hole from the bottom.

Droop of ailerons	$\frac{3}{4}$ inch.
Droop of elevator	Nil.

[1] Approximately.

POINTS TO OBSERVE WHEN OVERHAULING MACHINE.

See that the leading edges of the main planes are symmetrical about center line of machine.

Examine the bracing wires for length and tautness in the center section, and see that the split pins are in position and that all lock nuts are tight.

Check the dihedral.

Check the stagger.

Check the incidence.

Examine all main bracing wires for length and tautness, and see that all split pins are in position and that all lock nuts are tight.

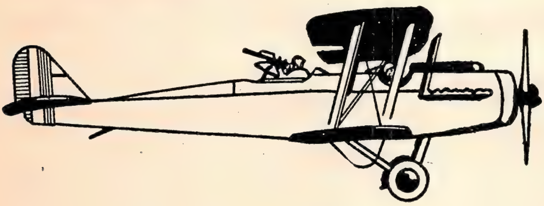

FIG. 69.—The De Haviland 4, 1917.

Examine all controls, control pulleys, and cables, and see that they work freely, and that turnbuckles on cables are locked.

Examine tail plane and see that it is set correctly, and is square with machine, and that all tail-plane bracing wires are correct both as to tautness and length, and that all split pins are in position and that all lock nuts are tight.

Examine rudder and fin and see that they are set straight and square with machine.

Examine undercarriage and skid.

Measure the droop of the ailerons and elevators.

Examine tank mountings and connections.

Examine engine mounting, engine controls, and engine accessories.

See that the interplane struts are straight.

DE HAVILAND NO. 6 (90-HORSEPOWER R. A. F. 1A).

List of principal dimensions.

Span of upper and lower main planes	[1] 35 feet 11⅛ inches.
Chord of upper and lower main planes	6 feet 4 inches.
Incidence of upper and lower main planes	4°.
Gap	6 feet.
Stagger	Nil.
Dihedral	2°.
Overall length	[1] 27 feet 4¼ inches.
Height	[1] 10 feet 9 inches.
Droop of ailerons	⅞ inch.
Droop of elevator	Nil.

[1] Approximately.

POINTS TO OBSERVE WHEN OVERHAULING MACHINE.

See that the leading edges of the main planes are symmetrical about center line of machine.

Examine the bracing wires for length and tautness in the center section, and see that the split pins are in position, and that all lock nuts are tight.

Check the dihedral.

Check interplane struts for being vertical with machine in flying position.

Check the incidence.

See that the interplane struts are straight.

Examine all main plane bracing wires for length and tautness, and see that all split pins are in position, and that all lock nuts are tight.

Examine all controls, control pulleys and cables, and see that they work freely and that turnbuckles on cables are locked.

Examine tail plane and see that it is set correctly and is square with machine, and that all tail plane bracing wires are correct, both as to tautness and length, and that all split pins are in position, and that all lock nuts are tight.

Examine rudder and fin and see that they are set straight and square with machine.

Measure the droop of the ailerons and elevators.

Examine undercarriage and skid.

Examine tank mountings and connections.

Examine engine mounting, engine controls, and engine accessories.

S. E. 5A (200-HORSEPOWER HISPANO-SUIZA).

List of principal dimensions.

Span of upper and lower main planes	26 feet 7½ inches.
Chord of upper and lower main planes	5 feet.
Incidence of upper and lower main planes	5°.
Gap	4 feet 7 inches.
Stagger	18 inches.
Dihedral	5°.
Overall length	20 feet 11 inches.
Height	9 feet 6 inches.
Droop of ailerons	¾ inch.
Incidence of center line of tail plane with knob on handwheel opposite the word "normal" on strut	5°.
With pilot's control stick leaning forward 10° from the vertical elevators	Horizontal.

POINTS TO OBSERVE WHEN OVERHAULING MACHINE.

See that leading edges of main planes are symmetrical about center line of machine.

Examine the bracing wires for length and tautness in the center section and see that all split pins are in position and that all lock nuts are tight.

Check the dihedral.

Check the stagger.

Check the incidence.

Examine all main plane bracing wires for length and tautness, and see that all split pins are in position and that all lock nuts are tight.

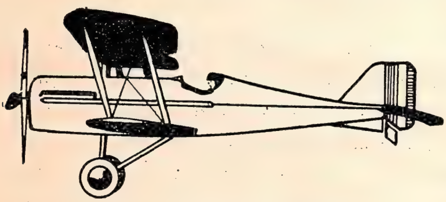

FIG. 70.—The S. E. 5, 1917.

Examine all control pulleys and cables, and see that they work freely and that all turnbuckles on cables are locked.

Examine tail plane and see that it is set correctly and is square with machine and that all bracing wires are correct both as to tautness and length and that lock nuts are tight.

See that the tail plane actuating gear works freely.

Examine rudder and fins and see that they are set straight and square with machine.

Examine the setting of ailerons and elevator.

Examine undercarriage and skid.

Examine tank mountings, engine controls, and engine accessories and see that pins through control arms and levers are not worn.

See that security bolts for gun and mount are all tight.

SOPWITH 1½ STRUTTER (110-HORSEPOWER CLERGET).

List of principal dimensions.

Span of upper and lower main planes	33 feet 6 inches.
Chord of upper and lower main planes	5 feet 6 inches.
Incidence of upper and lower main planes	2° 10″.
Dihedral	2° 23′.
Gap	5 feet 4¾ inches.
Stagger	24 inches.
Overall length	25 feet 3 inches.
Height	10 feet 3 inches.
Droop of ailerons	Nil.
Incidence of tail plane with control neutral	2°.
Droop of elevators with tail plane in mean position	Nil.

POINTS TO OBSERVE WHEN OVERHAULING MACHINE.

See that the leading edges of main planes are symmetrical about center line of machine.

Examine the center section (K. rib) bracing wires for length and tautness, and see that the split pins are in position and that all lock nuts are tight.

Check the dihedral.

Check the stagger.

Check the incidence.

See that the interplane struts are straight.

Examine all main plane bracing wires for length and tautness, and see that all split pins are in position.

FIG. 71.—The Sopwith camel, 1917.

Examine all controls, control pulleys and cables and see that they work freely, and that all turnbuckles on cables are locked.

Examine tail plane and see that it is set correctly, and is square with machine, and that all tail plane bracing wires are correct both as to length and tautness, and that all split pins are in position and that all lock nuts are tight.

Examine tail plane actuating gear and see that it works freely.

Examine rudder and fin and see that they are set straight and square with machine.

Measure the droop of the ailerons and elevators.

Examine undercarriage and tail skid.

Examine tank mountings and connections.

Examine engine mounting, engine controls, and engine accessories.

SOPWITH BIPLANE F–1 (130-HORSEPOWER CLERGET).

List of principal dimensions.

Span of upper and lower main planes	28 feet.
Chord of upper and lower main planes	4 feet 6 inches.
Incidence of upper and lower main planes	2°.
Gap at fuselage	5 feet.
Stagger at center section	18 inches.
Stagger at outer struts	$18\frac{5}{16}$ inches.
Dihedral of upper main planes	Nil.
Dihedral of lower main planes	5°.
Overall length	18 feet 9 inches.
Height	8 feet 6 inches.
Incidence of tail plane (center line)	$1\frac{1}{2}$°.
Droop of ailerons	Nil.

Elevators are in continuation of tail plane when upper front edge of tubular reinforcement in pilot's control stick; just beneath, the handle is 9¾ inches, horizontally, in rear of dashboard.

POINTS TO OBSERVE WHEN OVERHAULING MACHINE.

See that the leading edges of the main planes are symmetrical, about center line of machine.

Examine the bracing wires for length and tautness in the center section, and see that the split pins are in position, and that all lock nuts are tight.

Check the dihedral of lower main planes.

Check the stagger.

Check the incidence.

See that the interplane struts are straight.

Examine all main plane bracing wires for length and tautness, and see that all split pins are in position.

Examine all controls, control pulleys and cables, see that they work freely, and that turnbuckles on cables are locked.

Examine tail plane and see that it is set correctly and is square with machine and that all tail plane bracing wires are correct, both as to tautness and length, and that all split pins are in position, and that all lock nuts are tight.

Examine rudder and fin and see that they are set straight and square with machine.

Measure the droop of the ailerons and elevators.

Examine undercarriage and skid.

Examine tank mountings and connections.

Examine engine mountings, engine controls, and engine accessories.

Examine cartridge drums and see that they are secure and do not foul in carburetor.

SOPWITH DOLPHIN 5-F1 (200-HORSEPOWER HISPANO-SUIZA).

List of principal dimensions.

Span of upper and lower main planes	[1] 32 feet 6 inches.
Chord of upper and lower main planes	4 feet 6 inches.
Incidence of upper and lower main planes	1¾°.
Stagger (back)	12 inches.
Dihedral, upper and lower main planes	2½°.
Over-all length	[1] 22 feet 3 inches.
Height	8 feet 6 inches.
Droop of ailerons (with pilot's control stick central)	Nil.
Droop of elevator (with top of handle of pilots control stick 8 inches horizontally in rear of dashboard)	Nil.

[1] Approximately.

POINTS TO OBSERVE WHEN OVERHAULING MACHINE.

See that the leading edges of the main planes are symmetrical about center line of machine.

Examine the bracing wires for length and tautness in the center section, and see that the split pins are in position and that all lock nuts are tight.

Check the dihedral.

Check the stagger.

Check the incidence.

See that the interplane struts are straight.

Examine all main plane bracing wires for length and tautness, and see that all split pins are in position.

Examine all controls, control pulleys and cables, and see that they work freely and that turnbuckles on cables are locked.

Examine tail plane and see that it is set correctly and is square with machine, and that all tail bracing wires are correct both as to tautness and length, and that all split pins are in position and that all lock nuts are tight.

Examine rudder and fin and see that they are set straight and square with machine.

Check the setting of the ailerons and elevators.

Examine undercarriage and skid.

Examine tank mountings and connections.

Examine engine mounting, engine controls, and engine accessories.

SPAD BIPLANE, TYPE S VII (150-HORSEPOWER HISPANO-SUIZA).

List of principal dimensions.

Span of upper main planes	25 feet 8 inches.
Span of lower main planes	[1] 25 feet.
Chord of upper main planes	4 feet 7 inches.
Chord of lower main planes	4 feet 2 inches.
Incidence of upper main planes	2°.
Incidence of lower main planes	$1\frac{1}{2}$°.
Dihedral	Nil.
Gap	3 feet $8\frac{1}{2}$ inches.
Stagger	45 mm.
Droop of ailerons	$\frac{1}{4}$ inch.
Droop of elevators (with pilot's control stick $\frac{3}{4}$ in forward)	Nil.
Overall length	20 feet $3\frac{1}{2}$ inches.
PB	[2] 10 feet $5\frac{5}{8}$ inches.
BR	[2] 17 feet $\frac{1}{8}$ inch.

where:

P is center of propeller boss.

B is center of bolt at foot of front outer interplane strut.

R is center of lower front bolt on side of rudder plate.

---

[1] Approximately.

[2] Approximate measurements.

POINTS TO OBSERVE WHEN OVERHAULING MACHINE.

See that leading edges of main planes are straight (by sighting along edge).

Examine all bracing wires for length and tautness in the center section, and see that split pins are in position.

Check planes for level (no dihedral).

Check planes for overhang (the term "Overhang" is used in preference to stagger, as the interplane struts are vertical and overhang is caused by lower main planes having a smaller chord than upper main plane.

FIG. 72.—The Spad, 1917.

Check planes for incidence.

See that interplane struts are straight and that safety pins are in position.

Examine all main-plane bracing wires for length and tautness and see that all split pins are in position.

Examine all cables and controls and see that same work freely and that all turnbuckles on cables are locked.

Examine tail plane and see that it is correctly set and is square with machine and that all tail-plane bracing stays are correct both as to length and tautness, and that all split pins are in position.

NIEUPORT SCOUT (130-HORSEPOWER CLERGET).

List of principal dimensions.

Span of upper main planes	8 meters, 160 millimeters.
Span of lower main planes	7 meters, 800 millimeters.
Chord of upper main planes	1 meter, 233 millimeters.
Chord of lower main planes	720 millimeters.
Incidence of upper main planes	1° 50 feet.
Incidence of starboard lower main planes	4°
Incidence of port lower main plane:	
At root	4°
At wing tip (to allow for propeller torque)	5°
Dihedral of upper main planes	0°
Dihedral of lower main planes	2° 20 feet.
Rake of upper main planes	2° 20 feet.
Rake of lower main planes	[1] 3° 30 feet.
Angle between V outer struts	36° 19 feet.
Stagger at V outer struts	645 millimeters.
Stagger at V outer struts	710 millimeters.
Overall length	6 meters.
Height	2 meters, 400 millimeters.
Angle of incidence of tail plane	0°.
(Top longerons, level.)	
Undercarriage track	1 meter, 600 millimeters.

[1] Approximate.

POINTS TO OBSERVE WHEN OVERHAULING MACHINE.

See that the upper main planes are level (no dihedral).

Check main planes for being square with fuselage and propeller boss.

Examine the bracing wires in the center section for length and tautness and see that all split pins are in position and that all splices are sound.

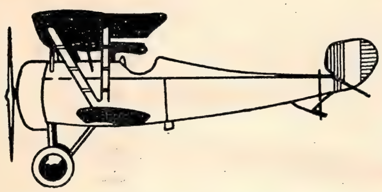

FIG. 73.—The Baby Nieuport, 1916.

Check main planes for incidence and stagger.

Examine all main plane bracing wires for length and tautness and see that all split pins are in position and that all splices are sound.

Examine all cables and controls and see that same work freely, and that turnbuckles on cables are locked and that all splices are sound.

Examine tail plane and see—

(*a*) That it is level and at zero incidence.

(*b*) That it is square with machine.

(*c*) That tail plane bracing stays are correct as to length, and that split pins are in position.

(*d*) That safety pin on top of sternpost is in position.

Examine rudder and see that it is set square with machine.

See that, with pilot's control stick central, there is no droop on the ailerons and elevators.

Examine the undercarriage.

Examine tank mountings and connections.

Examine engine mounting, engine controls, and accessories.

Examine gun mounting and gear and check for correct position with regard to the engine; also check sights for alignment with gun.

CHAPTER XIX.

DEFINITIONS IN GEOMETRY, PHYSICS, AND MECHANICS.

Angle.—An angle is a figure formed by two straight lines diverging from a point. An angle is measured in degrees on the circumference of an imaginary circle.

Acute angle: An angle of less than 90°.

Right angle: An angle containing 90°.

Obtuse angle: An angle of more than 90° and less than 180°.

Arc.—Any portion of the circle's circumference.

Chord.—The straight line connecting the extremities of an arc.

Circle.—A plane figure bounded by a curved line, every point in which is equally distant from a point within, called the center.

Circumference.—The curved line bounding a circle.

Concave.—Curving inward toward the center of a body, referring to the inner side of a curve—for instance, the inside of a cup is concave.

Convex.—Curving outward from the center of a body, referring to the outside of a curve—for instance, the surface of a ball is convex.

Degree.—The unit of measurement of a circle's circumference: one three-hundred-and-sixtieth part of a circle's circumference.

Diameter.—A straight line passing through the center of a circle having its extremities in the circumference. The diameter of a circle is twice the length of its radius.

Dihedral angle.—An angle formed by the intersection of two plane surfaces—for instance, two wing panels.

Eccentric.—Referring to circles contained one within another, but having different centers.

Concentric.—Referring to circles contained one within another having a common center.

Horizontal.—A straight line drawn parallel to the normal line of the earth's surface, to the horizon or to still water, is a horizontal line.

Lateral.—Pertaining to the sideways or width measurement of an object.

Longitudinal.—Pertaining to the measurement of an object in respect to its length—lengthwise.

Parallel.—Straight lines drawn in the same plane which are equally distant from each other at all points are parallel lines. Such lines never would meet even if indefinitely extended.

Perpendicular.—When one straight line intersects another at right angles to it, each line is said to be perpendicular to the other. In the same way, plane surfaces may be perpendicular.

Radius.—A straight line drawn from the center of a circle to its circumference, one-half the circle's diameter.

Sector.—That portion of a circle contained within two radii and the intercepted arc.

Segment.—That portion of a circle contained within an arc and its chords.

Tangent.—A straight line touching a circle's circumference at but one point and perpendicular to its radius at that point is a tangent.

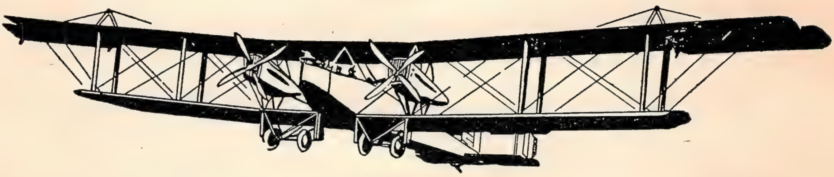

FIG. 74.—The Handley Page, 1916.

Vertical.—A straight line drawn in the direction of the attraction of gravity is a vertical line; for instance, a plumb line.

PHYSICAL AND MECHANICAL.

Distortion.—Refers to a permanent change of shape in a body resulting from an overload and incapable of repair as distinguished from a body's temporary change of shape or strain which can be repaired.

Force.—An active power which changes or tends to change the condition of a body in respect to its rest or motion.

Gravity.—The attraction of bodies toward the earth's center.

Inertia.—The tendency of a body to remain in its existing state of rest or of motion.

Momentum.—The quantity of motion in a moving body, the tendency of which is to maintain that motion in a straight line. Momentum is the product of mass and velocity.

Stress.—The internal resistance of a body to an external applied force. Stresses of four kinds are present in the airplane when in flight.

(*a*) Tension: That stress which resists the pulling apart or lengthening force applied at the ends of a body, such as a tightened wire.

(*b*) Compression: That stress which resists the compressive or crushing force applied to a body such as a wing strut.

(*c*) Shear: That stress which resists the force tending to shear or pull one part of a body past the other in a direction parallel to their plane of contact. For instance, a clevis pin sheared off in a fitting.

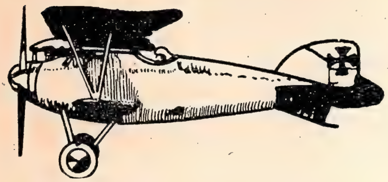

Fig. 75.—The Albatros III, 1917.

(*d*) Torque: That stress which resists a twisting or rotating force applied to a body such as the crankshaft of an engine.

Strain.—Refers to the effect produced when the applied force overcomes the internal resistance, causing a change of form in the body, which may be only temporary.

(*a*) Elongation: The strain resulting from overcoming the stress of tension, the body being stretched or lengthened.

(*b*) Contraction: The strain resulting from overcoming the stress of compression, the body being crushed or compressed.

(*c*) Deflection: The strain resulting from overcoming the stress of shear, the body being bent or deflected.

(*d*) Torsion: The strain resulting from overcoming the stress of torque, the body being twisted.

Velocity.—The rate of speed or of motion.

CHAPTER XX.

TERMS USED IN AERONAUTICS.

Airfoil.—A thin, winglike, rigid structure, flat or curved, designed to obtain reaction from the air by its movement through it.

Aeronautics.—The science of aerial navigation.

Ailerons.—Movable sections of wing panels forming outer rear part used for banking or turning and to give the airplane lateral control.

Aircraft.—Any form of craft designed for the navigation of the air—airplanes, balloons, dirigibles, helicopters, kites, kite balloons, ornithopters, gliders, etc.

Airplane.—A form of aircraft heavier than air, which has wing surfaces for support, with stabilizing surfaces, rudders for steering, and power plant for propulsion through the air.

Pusher: An airplane with propeller behind the wings.

Tractor: An airplane with propeller in front of the wings.

Air-speed meter.—An instrument designed to measure the velocity of an aircraft with reference to the air through which it is moving.

Altimeter.—An instrument mounted on an aircraft to continuously indicate its height above the earth.

Anemometer.—An instrument for measuring the velocity of the wind or air currents.

Angle.—Of attack: The angle formed by the chord of the wing and the line of the relative wind.

Of incidence: The angle formed by the chord of the wing and a line parallel to the true flying level of the airplane.

Critical: The angle of attack at which the lift is a maximum and above which the airplane will stall.

Gliding: The angle made by the horizontal and the natural path taken by an airplane when gliding to earth with power off.

Aspect ratio.—The ratio of the width or chord of any airfoil to its length or span.

Bank.—To tilt an airplane sideways when turning to left or right.

Barograph.—An instrument used to record variations in barometric pressure on an airplane. This record is made continuously on a chart moved by clockwork, and from it the altitude of the plane at any moment of its flight can be determined.

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Bay.—The cubical space roughly inclosed between upper and lower wing panels and the four struts connecting them.

Biplane.—An airplane with two main wings, placed one above the other.

Camber.—The curvature or curved outline given to an airfoil's surface. Measured from the chord of the curve and given as the ratio of the maximum height of the curve to the length of the chord. Top camber refers to the airfoil's top surface and bottom camber to its bottom surface.

Capacity.—The lifting capacity is the maximum flying load of an aircraft. The carrying capacity is the excess of the lifting capacity over the dead-weight of the airplane.

Cata-hedral.—A negative dihedral wing arrangement.

Ceiling.—The maximum altitude to which an airplane can ascend.

Center of gravity.—The center of weight.

Controls.—The complete system used for steering, elevating, balancing, and speed regulation of an airplane.

Chord, riggers.—A straight line from the entering to trailing edge of a panel touching its under surface at both points. Length of chord, the distance from leading to trailing edge of a panel.

Decalage.—The difference in the angle at which two panels are set; for instance, the upper panel of a biplane as compared with the lower panel or the wing panels as compared with the horizontal stabilizer.

Dead surface.—Referring to a surface which exerts no lifting power.

Declature.—An increase in the length of the chord of the upper panel as compared with that of the lower.

Dihedral angle.—The true dihedral angle is formed by two intersecting planes, which, in our work, are represented by the wing panels. For purposes of measurement the angle formed by the upward rise of the wings and a line drawn parallel to the entering edge of the center section is equivalent to the dihedral angle.

Drift.—Refers, roughly, to any retarding force acting against the airplane in flight and may be:

Active drift: Such as the wind or a tornado.

Passing drift: The head-on resistance of the struts, wires, landing gear, etc., to the air.

Skin friction: The friction of the air with roughness of surface produced by muddy wings, torn fabric, etc.

Droop.—A wash-in or gradual increase of the panel's angle of incidence from butt to tip, put there to obviate propeller torque.

Dual control.—A double system of control.

Elevator.—A horizontal rudder for steering the airplane upward or downward in the air.

Empennage.—Referring to the tail unit, including the rudder, elevators, horizontal and vertical stabilizers.

Entering edge.—That edge of panel which enters the air, the front edge.

Factor of safety.—The breaking strength of a body divided by the maximum stress it is usually called upon to bear.

Fin.—A fixed air foil or vertical stabilizer used to give directional stability to an airplane.

Flying boat.—An airplane designed so that its body acts as a boat on the water, carrying the empennage and passengers.

Flying position.—The position in which airplanes must be placed for rigging, having its top longerons level laterally and longitudinally.

Foot-pound.—A measure of work; 1 pound raised 1 foot.

Gap.—The perpendicular distance between the chords of the upper and lower panels of a biplane.

Glider.—A form of aircraft similar to an airplane but without any power plant.

Gyroscope.—A heavy wheel revolving at speed which has a tendency to maintain its plane of rotation against disturbing forces.

Head resistance.—Drift: The resistance of the air to the passage of a body.

Helicopter.—A form of aircraft whose support is the air derived from the vertical thrust of propellers.

Inclinometer.—An instrument for measuring the angle made by any axis of an aircraft with the horizontal.

Keel surface.—All the surface to be seen when viewing an airplane from the side—sides of struts, fuselage, wires, etc.

Kite.—A form of aircraft without any other propulsion than the towline pull, whose support is derived from the force of the wind moving past its surface.

Landing gear.—The understructure designed to carry the load when resting on or running on land or water.

Lift.—Any upward forces acting upon an airplane in flight.

Lift-drift ratio.—The proportion of lift to drift or resistance.

Monoplane.—An airplane having one wing surface.

Multiplane.—An airplane having three or more wing surfaces.

Nacelle.—The body of a pusher-type airplane.

Negative ailerons.—Ailerons making a negative angle with wind in flight, raised above trailing edge of panel.

Ornithopter.—A form of aircraft deriving its support and propulsion from flapping wings.

Overhang.—That part of the upper panel extending beyond the span of the lower panel.

Newton's laws of motion.—1. If a body be at rest it will remain at rest, or if in motion it will move uniformly in a straight line until acted upon by some force.

2. The rate of change of the quantity of motion (momentum) is proportional to the force which causes it, and takes place in the direction of the straight line in which the force acts. If a body be acted upon by several forces it will obey each as though the others did not exist, and this whether the body be at rest or in motion.

3. To every action there is opposed an equal and opposite reaction.

Pancake.—A straight vertical drop, due to stalling.

Pitot tube.—A tube with an end open squarely to the fluid stream used as a detector of an impact pressure, often used in conjunction with a gauge to determine the velocity of aircraft (fixed usually on one of the front wing struts).

Power, horse.—One horsepower represents a force sufficient to raise 33,000 pounds 1 foot in a minute.

Positive ailerons.—Ailerons making a positive angle with the wind in flight, lowered below trailing edge.

Propeller.—An air screw.

Pitch of propeller: The distance a propeller advances in one revolution, supposing the air to be solid.

Slip of propeller: The pitch minus the actual distance traveled by the propeller in one revolution.

Retreat.—Back-sweep wings with the tips to the rear of the wing center.

Rudder.—The hinged airfoil used for steering the airplane right or left.

Stagger.—The shortest distance from the entering edge of the lower panel to a plumb line dropped from the leading edge of the upper panel, airplane being in true flying position. It is positive stagger when the upper panel projects forward over the lower one.

Seaplane.—An airplane equipped with floats or pontoons for operation from the water.

Side slipping.—Slipping toward the center of a turn as a result of too much bank. The opposite of skidding.

Skidding.—Sliding away from the center of a turn as a result of too little bank.

Span.—The distance from wing tip to wing tip taken at widest point.

Stability.—Refers to the quality of being stable or steady. Inherent stability in an airplane due to fixed arrangement of its parts acts to oppose any deviation from its course whether the pilot so desires or not.

Streamline shape.—One in which the thickest part is in front and tapers to a point in the rear, providing smooth lines of flow for the

air which has been thrust aside at the front to flow back without eddies to the rear.

Sweep back.—See retreat.

Tachometer.—An instrument recording the motor speed in revolutions of the crank shaft per minute.

Tail spin.—A condition in which the tail revolves about a vertical line passing through the center of gravity.

Thrust.—The forward pull of the propeller.

Trailing edge.—The rear edge of any airfoil such as a wing panel.

Torque.—Is simply a reaction of the motor in the direction opposite to which it turns, tending to turn the airplane over in that direction.

Triplane.—An airplane with three wings, one above the other.

Turnbuckles.—A form of wire tightener, consisting of a hollow barrel threaded at each end to receive an eye bolt.

Vetting.—The process of sighting by eye along edge of panels, etc., to determine their alignment.

Wash-in.—Angle of incidence increased toward wing tip.

Wash-out.—Angle of incidence decreased toward wing tip.

Weight.—Is a measure of the force of the earth's attraction (gravity) upon a body. The standard unit of weight in this country is 1 pound and is the force of the earth's attraction on a piece of platinum, called the standard pound, deposited with the board of trade in London. At the center of the earth a body will be attracted with equal force in every direction. It will, therefore, have no weight, though its mass is unchanged. Gravity, of which weight is a measure, decreases with increase of altitude.

CHAPTER XXI.

HANDY TABLES FOR THE AVIATION MECHANIC.

The fundamental unit of the metric system is the meter, the unit of length. From this the units of capacity (liter) and of weight (gram) were derived. All other units are the decimal subdivisions or multiple of these. These three units are simply related; e. g., for all practical purposes 1 cubic decimeter equals 1 liter, and 1 liter of water weighs 1 kilogram. The metric tables are formed by combining the words meter, gram, and liter with the six numerical prefixes, as in the following tables:

Prefixes.	Meaning.			Units.
Milli-=	One thousandth	1/1000	.001	Meter for length. Gram for weight or mass. Liter for capacity.
Centi-=	One hundredth	1/100	.01	
Deci-=	One tenth	1/10	.1	
Unit	One		1	
Deka-=	Ten	10/1	10	
Hecto-=	One hundred	100/1	100	
Kilo-=	One thousand	1000/1	1,000	

"International Metric System," Bureau of Standards, Washington, D. C.

Units of length.

	Meter.
Millimeter	0.001
Centimeter	.01
Decimeter	.1
Meter [1]	1
Dekameter	10
Hectometer	100
Kilometer	1,000

Where miles are used in England and the United States for measuring distances, the kilometer (1,000 meters) is used in metric countries. The kilometer is about 5 furlongs. There are about 1,600 meters in a status mile, 20 meters in a chain, and 5 meters in a rod.

The meter is used for dry goods, merchandise, engineering construction, building, and other purposes where the yard and foot are used. The meter is about a tenth longer than the yard.

The centimeter and millimeter are used instead of the inch and its fractions in machine construction and similar work. The centi-

[1] One meter equals 39.37 inches, exactly.

meter, as its name shows, is the hundredth of a meter. It is used in cabinet work, in expressing sizes of paper, books, and many cases where the inch is used. The centimeter is about two-fifths of an inch, and the millimeter about one twenty-fifth of an inch. The millimeter is divided for finer work into tenths, hundredths, and thousandths.

If a number of distances in millimeters, meters, and kilometers are to be added, reduction is unnecessary. They are added as dollars, dimes, and cents are now added. For example, "1,050.25 meters" is not read "1 kilometer, 5 dekameters, 2 decimeters, and 5 centimeters"; but "1,050 meters, 25 centimeters," just as "$1,050.25" is read "one thousand and fifty dollars, twenty-five cents."

AREA.

The table of area is formed by squaring the length measures, as in our common system. For land measure 10 meters square is called an "Are" (meaning area). The side of 1 are is about 33 feet. The hectare is 100 meters square, and, as its name indicates, is 100 ares, or about $2\frac{1}{2}$ acres. An acre is about 0.4 hectare. A standard United States quarter section contains almost exactly 64 hectares. A square kilometer contains 100 hectares.

For smaller measures of surface the square meter is used. The square meter is about 20 per cent larger than the square yard. For still smaller surfaces the square centimeter is used. A square inch contains about $6\frac{1}{2}$ square centimeters.

VOLUME.

The cubic measures are the cubes of the linear units. The cubic meter (sometimes called the stere, meaning "solid") is the unit of volume. A cubic meter of water weighs a metric ton and is equal to 1 kilometer. The cubic meter is used in place of the cubic yard and is about 30 per cent larger. This is used for "cuts and fills" in grading land, measuring timber, expressing contents of tanks and reservoirs, flow of rivers, dimensions of stone, tonnage of ships, and other places where the cubic yard and foot are used. The thousandth part of the cubic meter (1 cubic decimeter) is called the liter. (See table of capacity units.)

For very small volumes the cubic centimeter (c. c. or $cm.^3$) is used. This volume of water weights a gram, which is the unit of weight or mass. There are about 16 cubic centimeters in a cubic inch. . The cubic centimeter is the unit of volume used by chemists as well as in pharmacy, medicine, surgery, and other technical work. One thousand cubic centimeters make 1 liter.

Units of capacity.

	Liter.
Milliliter	0. 601
Centiliter	. 01
Deciliter	. 1
Liter [1]	1
Dekaliter	10
Hectoliter	100
Kiloliter	1, 000

The hectoliter (100 liters) serves the same purpose as the United States bushel (2,150.42 cubic inches) and is equal to about 3 bushels or a barrel. A peck is about 9 liters. The liter is used for measurements commonly given in the gallon, the liquid and dry quarts, a liter being 5 per cent larger than our liquid quart and 10 per cent smaller than the dry quart. A liter of water weighs exactly a kilogram, i. e., 1,000 grams. A thousand liters of water weigh 1 metric ton.

Units of weight (or mass).

	Gram.
Milligram	0. 001
Centigram	. 01
Decigram	. 1
Gram	1
Dekagram	10
Hectogram	100
Kilogram [2]	1, 000

Measurements commonly expressed in gross tons or short tons are stated in metric tons (1,000 kilograms). The metric ton comes between our long and short tons and serves the purpose of both. The kilogram and "half kilo" serve for everyday trade, the latter being 10 per cent larger than the pound. The kilogram is approximately 2.2 pounds. The gram and its multiple and divisions are used for the same purposes as ounces, pennyweights, drams, scruples, and grains. For foreign postage, 30 grams is the legal equivalent of the avoirdupois ounces.

Feet.	Meters.	Miles.	Kiloms.	Gallons.	Liters.
1	0.3	1	1.6	1	4.5
2	.6	2	3.2	2	9.0
3	.9	3	4.8	3	13.6
4	1.2	4	6.4	4	18.2
5	1.5	5	8.0	5	22.7
6	1.8	6	9.6	6	27.3
7	2.1	7	11.2	7	31.8
8	2.4	8	12.8	8	36.3
9	2.7	9	14.5	9	40.9
10	3.0	10	16.1	10	45.4

[1] One liter equals 1.05668 liquid quarts or 0.9081 dry quart.
[2] One kilogram equals 2,204622 avoirdupois pounds.

Power.

One horsepower=375 miles=pounds per hour.
One horsepower=33,000 feet=pounds per minute.
One horsepower=550 feet=pounds per second.
One horsepower=0.746 kilowatts.

Volume.

One gallon=8 pints.
One gallon=160 fluid ounces.
One gallon=0.16 cubic foot.
One gallon=4.546 liters.
One United States gallon=231 cubic inches.
One liter=0.1m ^{3}.
One liter=1.76 pints.
One liter=0.22 gallon.

Degrees.	Sine.	Tangent.
0	0.00000	0.00000
1	.01745	.01746
2	.03490	.03492
3	.05234	.05241
4	.06976	.06993
5	.09716	.08749
6	.10453	.10510
7	.12187	.12278
8	.13917	.14054
9	.15643	.15838
10	.17365	.17633
11	.19081	.19438
12	.20791	.21256

Length.

One inch=2.54 centimeters.
One foot=0.305 meter.
One yard=0.914 meter.
One mile=5,280 feet.
One mile=1,760 yards.
One mile=1.61 kilometers.
One sea mile=6,080 feet.
1° Equator=60 sea miles.
One minute=3.28 feet.

Area.

One foot ^{2}=144 inches^2.
One foot ^{2}=0.093m ^{2}.
One m ^{2}=10.76 feet ^{2}.
One yard ^{2}=0.836m ^{2}.
One acre=4,840 yards ^{2}.
One acre=4,046.7m ^{2}.
One square mile=640 acres.

Weight

One ounce equals 28.35 grams.
One pound equals 16 ounces.
One pound equals 0.4536 kilogram.
One ton equals 2,240 pounds.

One ton equals 1,016.05 kilograms.
One United States ton equals 2,000 pounds.
One kilogram equals 2.2 pounds.

Velocity.

One mile per hour equals 1.46 feet per second.
One mile per hour equals 88 feet per minute.
One knot equals 1.152 miles per hour.
One foot per second equals 0.685 mile per hour.
One meter per second equals 2.25 miles per hour.

Wind.		
Altitude.	Velocity (miles per hour).	Kilometers (per hour).
1,000	10	16.09
2,000	20	32.18
3,000	25	40.22
4,000	28	45.05
6,000	30	48.05
8,000	32	51.48

Sound in air.—1,142 feet per second.

Mensuration.

Surfaces: Triangle equals base times one-half perpendicular; circle equals d^2 times 0.7854.

Sector=arc times $\frac{1}{2}$ radius.
Parabola=base times $\frac{2}{3}$ height.
Elipse=major axis times 0.7854 minor axis.
Cone=base area plus (base circle times $\frac{1}{2}$ slant height).
Sphere=$d^2 \times 3.14159$.

Volumes.

Cylinder=base area times length.
Sphere=$d^3 \times 0.5236$.
Segment=0.5236 height (height 2 plus 3 base radius).
Cone=base area times $\frac{1}{3}$ perpendicular.
Wedge=base area times $\frac{1}{2}$ perpendicular.

The circle.

Circumference=diameter$\times$3.14159.
Equal square=diameter$\times$0.886226.
Inscribed square=diameter$\times$0.7071.

Temperature.	
°F.	°C.
0	18
10	12
20	7
30	0
40	
50	
60	16
70	21
80	27
90	32
100	38
110	43
120	49
130	54
140	60
150	65
160	71
170	77
180	82
190	88

CHAPTER XXII.

POINTS TO NOTICE IN EXAMINING AN AIRPLANE.

ASSEMBLY.

1. Detailed description of landing gear assembly, giving any peculiarities of type or exceptions to the general rule.

2. Detailed description of tail unit assembly, giving method of aligning stabilizers or any exception to the general rule. Give exact description of attaching all control wires in this unit.

3. Detailed description of center section assembly, giving method of leveling fuselage, method of placing center section struts and systems of numbering, method of placing center section stagger. Show just where horses are placed under fuselage when level; exactly how center section is squared up.

4. Give method of assembling wings, with strut numbers, etc., and give method of putting wings on the plane.

ALIGNMENT.

1. How are the leading and trailing edges of the wings aligned? From what points are they sighted?
2. How much stagger is given wings? How measured?
3. How much dihedral angle? How measured?
4. How much sweepback, if any? How measured?
5. How large an angle of incidence? How measured?
6. How are ailerons aligned and in what position.
7. If any droop, how put in and how measured?
8. How tight are flying wires drawn up?
9. How tight are control wires drawn up?
10. How tight are drift wires drawn up?
11. What method of safetying turnbuckles is used?

MOTOR INSTALLATION.

1. Peculiarities of cooling systems and connections.
2. Oil and gasoline lines.

3. Ignition systems.

(*a*) Ignition connections.

(*b*) Type of spark plug used.

(c) Get all valves, breaker, and spark clearances in use.

1. Detail just how clearances are adjusted.

(*d*) Detail method of filling with gas, oil, and water.

1. Method of eliminating air pockets.

(*e*) Take note of any cooling, ignition, or carburetion troubles which arise on the field.

(*f*) Give in detail method of starting and cranking motor.

INSPECTION.

1. What systems of inspection are used? Explain in detail.

(REMARKS.—Sum up in this paragraph all the peculiarities of the airplane and compare with other airplanes. Give facts about it which you have picked up from factory mechanics and elsewhere.)

CONSTRUCTION.

1. Kinds of wood and where used.
2. Peculiarities of landing gear construction.
3. Features of wing panel construction and repair.
4. Features of fuselage construction, alignment, and repair.
5. Feature of empennage construction.
6. Feature of center section construction.
7. Feature of control construction and operation.
8. Sketch special fittings and describe in detail.
9. Give any other information or conclusions secured.

CHAPTER XXIII.

LIST OF GOOD AVIATION BOOKS.

Acquiring Wings, by W. B. Stout. A handy manual, explaining the principles of flight clearly and simply. Good drawings. New York. Moffat, Yard & Co. $0.75.

Aircraft Mechanics Handbook, by Fred H. Colvin. A collection of facts and figures about rigging, aviation engines, materials and fittings, instruments, aviation terms, etc. McGraw Hill Book Co., 239 West Thirty-ninth Street, New York City. $3.

Aviation Engines, by Victor Page. Very complete and many illustrations. N. W. Henly Publishing Co., New York City. $3.

Aviation Engine Chart, by Page. Shows the parts of the engine. N. W. Henly Publishing Co., New York City. $0.50.

Auto and Gas Engine Encyclopedia, by Dyke. Covers both automobile and aviation engines. Many illustrations and charts. A. L. Dyke, St. Louis, Mo. $3.50.

Airfare of To-day and of the Future, by E. C. Middleton. A discussion of the progress of aviation to date and possibilities of the future. Aeronautic Library, 280 Madison Avenue, New York City. $1.50.

Flight Without Formulæ, by Capt. Duchene. A discussion of the principles of flight for the student. Longman, Green & Co., New York. $2.75.

High Adventure, by James Norman Hall. The adventures of a flyer. Aeronautic Library, 280 Madison Avenue, New York City. $1.50.

Learning to Fly in the United States Army, by E. N. Fales. Takes up principles of flight, types of airplanes, rigging and construction, materials and inspection. McGraw Hill Book Co., 239 West Thirty-ninth Street, New York City. $1.50.

Manual of Military Aviation, by Maj. H. L. Muller, containing discussion of military air forces, uses of military airplanes, construction, equipment, etc. Geo. Banta Publishing Co., Menasha, Wis. $2.50.

Mechanics of the Airplane, by Capt. Duchene. A technical discussion of flight principles, with tables, formulæ, etc., for designers and students. Longman, Green & Co., New York City. $2.75.

Textbook of Military Aeronautics, by Henry Woodhouse. Aeronautic Library, New York City. $6.

The Aeroplane Speaks, by H. Barber. A clear explanation of the principles of flight and the operation of the parts of the aeroplane, with many drawings. Aeronautic Library, New York City. $3.

Winged Warfare, by Maj. W. A. Bishop, telling of his adventures on the front and giving practical advice from an experienced pilot. Aeronautic Library, 280 Madison Avenue, New York City. $1.50.

AVIATION MAGAZINES.

Aerial Age, weekly, $4 per year. Gives aviation news, discussions of new types of planes, technical articles, etc., 280 Madison Avenue, New York City.

Flying, monthly, $3 per year. General articles on aviation and airplanes, 280 Madison Avenue, New York City.

Aviation and Aeronautical Engineering, twice a month, $2 per year. Technical articles on aviation subjects, with good pictures. Gardner Moffat Co., 120 West Thirty-second Street, New York City.

Air Service Journal, weekly, $3 per year. News of the United States Army, Air Service.

Automotive Industries, weekly, $3 per year. News of aviation and articles on new airplanes and engines, as well as information about automobiles and tractors, 239 West Thirty-ninth Street, New York City.

GLOSSARY.

NOMENCLATURE OF THE AIRPLANE.

NOTE.—Letter "F" refers to front view, shown in figure 76, letter "S" to side view shown in figure 77, and letter "T" to top view, figure 78.

T 1. *Aileron.*—Movable section of wing panel forming outer rear part used for banking or turning and to give the airplane lateral control.

S 2. *Axle.*—Welded steel tubing, sometimes reinforced with wood filler.

S 3. *Axle collar.*—Machined brass to hold wheels on.

S 4. *Axle collar bolt.*—Hexagonal head, passes through axle collar and axle and is secured by castellated nut.

S–F 5. *Braces.*—Horizontal stabilizer, steel tubing, streamlined with spruce form and covered with linen tape and doped.

S 6. *Control wheel.*—Two in one; controls ailerons and elevators.

S 7. *Control yoke.*—Nonmagnetic tubing, fastened to seat rails by two trunnions and bearings. To this the control wheel is secured.

S–T 8. *Cockpit.*—Padded opening in fuselage for pilot.

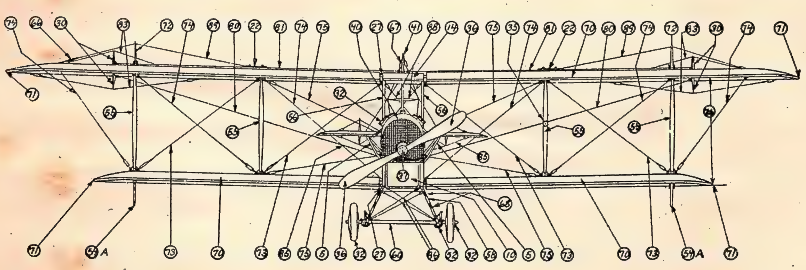

FIG. 76.—Front view.

T 9. *Cowl.*—Top over engine and cockpit sections of sheet metal or laminated wood.

F 10. *Cowl.*—Bottom; sheet metal.

F 11. *Clips.*—Fuselage, hold compression struts. To these diagonal bracing wires are attached.

T 12. *Distance piece.*—A long, round piece of spruce running full length of wing, used to prevent ribs from rolling over.

T 13. *Elevator.*—A controlling surface usually hinged to the horizontal stabilizer, the operation of which directs the airplane upward or downward.

S–T–F 14. *Center section panel.*—Upper panels are attached to center section panel. This panel is in the center section of the machine.

S 15. *Engine bed.*—Made of four laminations, usually two of spruce in the center, two of ash on the outside, used as engine supports. The engine bed is often made of ash or hickory without laminations.

S 16. *Engine bed protector.*—One-thirty-second inch sheet steel wrapped around bed to keep motor from sinking into wood.

S–T 17. *Edge, leading.*—The front edge of a panel.

T 17a. *Form, leading edge.*—The leading edge form is usually made of spruce.

T 18. *Edge, trailing.*—The rear edge of a panel or air foil.

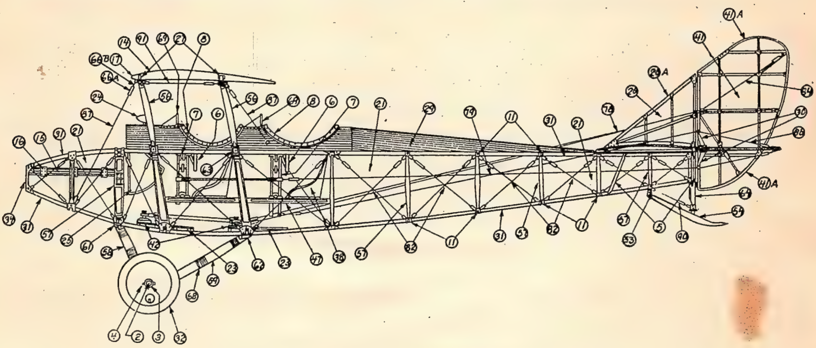

FIG. 77.—Side view.

T 18a. *Form, trailing edge.*—The trailing edge form is made of flattened steel tubing or spruce.

T 19. *Fabric.*—Irish linen or mercerized cotton, shrunk and tightened by applying about four coats of dope and two of varnish.

T–S 20. *Fin, vertical.*—A fixed surface used as a keel and to give the airplane directional stability.

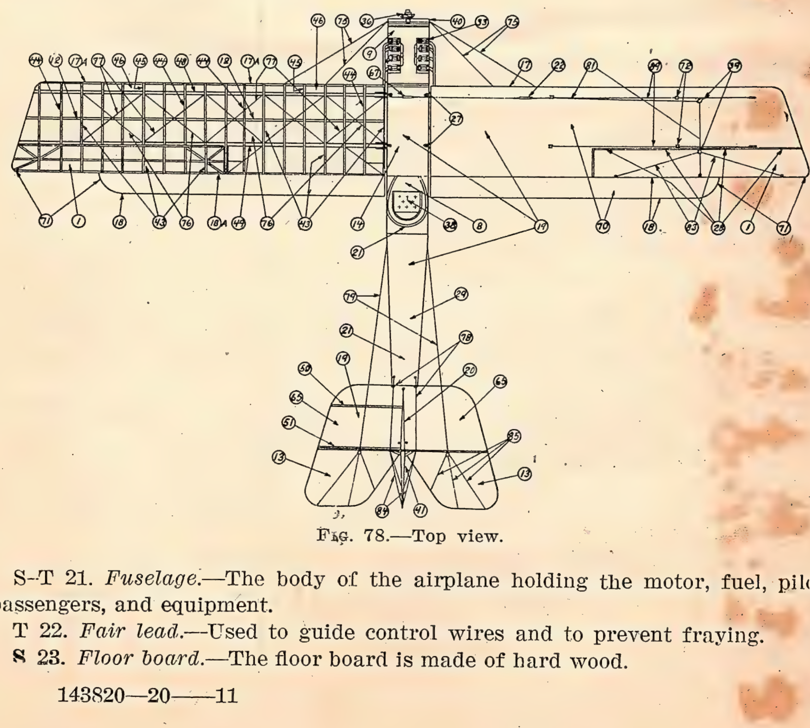

FIG. 78.—Top view.

S–T 21. *Fuselage.*—The body of the airplane holding the motor, fuel, pilot, passengers, and equipment.

T 22. *Fair lead.*—Used to guide control wires and to prevent fraying.

S 23. *Floor board.*—The floor board is made of hard wood.

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S 24. *Gasoline sight gauge.*—Showing quantity of fuel in tank.

S 25. *Gasoline tank.*—Heavy gauge tin.

F 26. *Gap.*—The perpendicular distance between chords of upper and lower wing panels of a biplane.

S–S–T 27. *Hinges, wing.*—Female on panels, male on center section, connected by wing hinge pin.

T 28. *Hinges, aileron.*—Male and female, connecting aileron to panel by hinge pin.

T–S 29. *Inspection cover or turtleback.*—A streamline cover, fastened to upper longerons by hinges or pins on each side; can be removed to inspect control wires and fuselage bracing wires.

S–F 30. *Control posts, horns, or pylons.*—Used on controlling surfaces as a lever to which are attached the control wires.

S 31. *Longeron.*—Generally white ash, running the full length of the fuselage.

S–F 32. *Landing gear wheels.*—Wire wheels with pneumatic tires, spokes and rims covered by fabric to streamline them.

F–T 33. *Motor.*—Power plant of airplane.

S 34. *Nose plate.*—Shaped sheet steel, used to connect four longerons and hold radiator in place.

F 35. *Pitot tube head.*—The air passes through head and metal tubing to indicator which measures the velocity of an aircraft with reference to the air through which it is moving, usually calibrated in miles per hour.

F–T 36. *Propeller.*—Oak, mahogany, or walnut, of laminated wood so shaped that its rotation about an axis produces a force (thrust) in the direction of its axis.

F 37. *Propeller hub.*—Machined steel, connects propeller to crankshaft.

S–T 38. *Pilot's seat.*—Upholstered bucket seat.

38a. *Passenger's seat.*—Upholstered bucket seat, or stool.

T 39. *Pulley.*—Ball-bearing pulley through which wire passes.

F–T 40. *Radiator.*—Contains 4½ gallons of water (in Curtiss) for cooling engine.

S–F–T 41. *Rudder.*—A controlling surfact hinged to the tailpost. Used to steer the airplane left or right.

S 41a. *Rudder frame.*—Flattened steel tubing.

S 42. *Rudder bar.*—Is dual control, ash bar, copper tipped, mounted in center on swivel and each end connected to control cable running to rudder. Has grooves for pilot's feet.

T 43. *Rib, compression.*—Bears the stress of compression produced by the tension of the internal bracing wires.

T 44. *Rib, lightening.*—A curved wooden rib assembled in a panel and used to give the panel its curvature and convey the lift from the fabric to the spars.

T 45. *Nose web.*—Same purpose as T 44, but runs only from leading edge form to front of main spar.

T 46. *Nose form.*—Often 3-ply wood, a curved form on top of T 45, its purpose being to take fabric and keep it to its proper curvature.

S 47. *Seat rail.*—Spruce I beam running from station behind pilot's seat to station in front of passenger's seat, supports pilot's and passenger's seats.

T 48. *Spar, main.*—Spruce I beam with panel to which all ribs, drift, and antidrift wires are attached.

T 49. *Spar, rear.*—Same as T 48 except in rear of panel.

T 50. *Spar, stabilizer main.*—Same as T 48 for horizontal stabilizer.

T 51. *Spar, stabilizer rear.*—In rear of horizontal stabilizer for bracing it, of lighter construction than wing spars.

F 52. *Shock absorber, landing gear.*—Rubber rope, to absorb and minimize the shock of landing.

S 53. *Shock absorber, tail skid.*—Rubber rope, to take up shock of landing on ash skid.

S 54. *Skid, tail.*—Made of white ash or other hardwood. Carries weight of rear portion of machine while on the ground. Acts as brake on landing.

F 54*a*. *Skid, wing.*—Made of rattan. Keeps wing tip from ground in case of bad landing.

F 55. *Strut, wing.*—Made of spruce because for its weight it resists compression best. Connects upper and lower panels.

S–F 56. *Strut, center section.*—Spruce, holds center section panel to which upper panels are attached.

S 57. *Strut, fuselage.*—Spruce, acts as spacer and braces the four fuselage longerons.

S–F 58. *Strut, landing gear, front.*—Spruce, reenforced by binding with linen twine.

S 59. *Strut, landing gear, rear.*—Same as S–F 58.

F 60. *Stream line spacer.*—Spruce, used as a stream lining for axle; also acts as a spacer for wheels. It is also called " spreader board."

S 61. *Socket, landing gear, front.*—Made of sheet steel, used to connect landing-gear strut to fuselage.

S 62. *Socket, landing gear, rear.*—Same as S 61.

S 63. *Socket, center section strut.*—Sheet metal, holds center section strut, fuselage strut, and diagonal bracing wires.

S 64. *Tail post.*—White ash, vertical post to which the four longerons are secured. The universal joint of tail skid and two hinges of rudder are also fastened to it.

T 65. *Horizontal stabilizer.*—A stabilizing surface attached by bolts to upper longerons and to which the elevators are hinged.

F–S 66a. *Turnbuckle barrel.*—Made of brass manganese alloy.

F–S 66b. *Turnbuckle fork.*—Fork with right-hand thread always attached to fixed portion of machine and eye with left-hand thread from which wire is taken. Made of hardened nickel steel.

T 67. *Turnbuckle, eye.*—Used to connect two wires so that two eye bolts can be used instead of fork.

F–S 68. *Winding, landing-gear strut.*—Linen twine, to reinforce and strengthen.

S 69. *Wind shield.*—Made of celluloid with aluminum frame, used to deflect wind and oil from passenger or pilot.

F–T 70. *Wing.*—The supporting surface of an airplane.

F–T 71. *Wing tip.*—The extreme right or left end of a wing.

F–T 72. *Cabane struts.*—Spruce with copper band at each end, used as a truss for overhang brace which supports upper panels overhang when machine is on the ground.

F 73. *Wires, landing.*—Stranded steel cable, used to take load of wings when airplane is landing on the ground.

F 74. *Wires, flying.*—Duplicated stranded steel cable, used to take load of airplane while flying and to prevent wings from collapsing upwards when flying.

F–T 75. *Wires, drift.*—Stranded steel cable, used to prevent wings from folding backward when flying.

T 76. *Wires, antidrift (wings).*—Piano wire, diagonal bracing wires used to adjust framework and to hold rigid.

T 77. *Wire, drift (wing).*—Piano wire for the same purpose as T 76.

S–T 78. *Wire, rudder control.*—Flexible stranded steel cable, used to connect rudder bar to control posts of rudder.

S–T 79. *Wire, elevator control.*—Flexible stranded steel cable, used to connect control yoke to control posts of elevators.

F 80. *Wire, aileron control.*—Flexible stranded steel cable, used to connect control wheel to aileron control posts.

T–F 81. *Wire, compensating or balance.*—Flexible stranded steel cable, used to balance and connect ailerons.

S 82. *Wire, fuselage, diagonal bracing.*—In forward half of fuselage these are duplicated stranded steel cables; in rear half, they are piano wire.

F–T 83. *Wire, aileron bracing.*—Piano wire, used to brace control posts and to prevent warping of ailerons.

S–T 84. *Wire, rudder bracing.*—Piano wire, serves the same purpose on the rudder.

F–T 85. *Wire, elevator bracing.*—Serves same purpose on the elevators.

F 86. *Wire, landing gear diagonal bracing.*—Heavy stranded steel cable, used to hold landing gear square and to take strains in landing.

S 87. *Wire, center section front brace and rear counter drift.*—Heavy stranded steel cable, used to adjust stagger on center section and hold it in place.

F 88. *Wire, center section front cross.*—Heavy stranded steel cable, used to hold center section rigid both when on the ground and when flying.

F–T 89. *Wire, overhang.*—Stranded steel cable, runs over cabane strut and takes load of overhang when airplane is on the ground.

S 90. *Wire, tail-post bracing.*—Piano wire, used to brace tail post and take strain from tail post in a fast landing.

S 91. *Wire, center-section tie.*—Stranded steel cable, used to take up stress imposed by front and rear brace wires.

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